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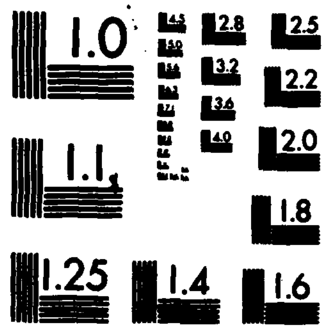

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Summary of ELF PVS Effective Noise Measurements 1976-1978

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PREFACE

This report was prepared under NUSC Project No. A59007, "ELF Propagation RDT&E" (U), Principal Investigator, P. R. Bannister (Code 3411), Navy Program Element No. 11401N and Project No. X0792-SB, Naval Electronic Systems Command, Communications Systems Project Office, D. Dyson (Code PME 110), Program Manager ELF Communication Dr. B. Kruger, (Code PME 110-X1).

The analysis and write up of this report was performed while the author was occupying the Research Chair in Applied Physics at the Naval Postgraduate School, Monterey, CA. The author would especially like to thank Professors Otto Heinz and John Dyer, and Dean Bill Tolles for recommending him to occupy this post and Code 63R, NAVSEA for sponsoring the Chair.

The Technical Reviewer for this report was Raymond F. Ingram.

Reviewed and Approved: 12 April 1983

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From August 1976 through December 1978, extremely low frequency (ELF) field-strength and effective-noise measurements were taken continuously in Connecticut and sporadically aboard operational submarines. This report summarizes the effective-noise measurements taken at both land (Connecticut) and sea locations during this period. The main conclusion is that there are often considerable differences in effective-noise levels measured at land and sea locations.

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GLOSSARY OF ABBREVIATIONS

APD	Amplitude probability distribution
ELF	Extremely low frequency
EW	East-west
GMT	Greenwich Mean Time
MSK	Minimum shift keying
NS	North-south
NUSC	Naval Underwater Systems Center
PVS	Propagation validation system
SNR	Signal-to-noise ratio
STIU	Signal timing and interface unit
TTY	Teletype
WTF	Wisconsin Test Facility

SUMMARY OF ELF PVS EFFECTIVE-NOISE MEASUREMENTS, 1976 TO 1978

INTRODUCTION

The ELF* propagation validation system (PVS) is composed of the U. S. Navy's extremely low frequency (ELF) Wisconsin Test Facility (WTF) and ELF receivers (AN/BSR-1) installed on submarines and at certain land sites. The WTF is located in the Chequamegon National Forest in north-central Wisconsin, about 8 km south of the village of Clam Lake. It consists of two 22.5-km antennas; one antenna is located approximately in the north-south (NS) direction and one is located approximately in the east-west (EW) direction. Each antenna is grounded at both ends. At 76 Hz, the electrical axis of the NS antenna is 14 deg east of north, while the electrical axis of the EW antenna is 114 deg east of north. The WTF antenna array can be steered electrically toward any particular location and its radiated power is approximately 1 W.

The AN/BSR-1 receiver is composed of an AN/UYK-20 minicomputer, a signal timing and interface unit (STIU), a rubidium frequency time standard, two magnetic-tape recorders, and a preamplifier. The message output is on a teletype (TTY), which is used to control the receiver. The submarine receiving antenna is a buoyant cable 1.6 cm in diameter with electrodes spaced 300 m apart on a 580-m transmission line.

The system uses minimum shift keying (MSK) modulation with a center frequency of 76 Hz. The signalling scheme uses block orthogonal coding to make maximum use of the limited transmitter power available. This scheme provides the most efficient use of the transmitter for short messages.

In the extremely low frequency band, atmospheric noise is the limiting factor to receiver performance under most operating conditions. The dominant source of atmospheric noise is radiation induced by lightning. Owing to the low attenuation rate of ELF radio waves, which makes long-range communication possible in this band, noise characteristics are affected not only by local thunderstorms but also by storms megameters away. The effect of local thunderstorms is to produce large spikes, while the effect of distant storms is a background noise with occasional spikes.

Because of the wide variation in worldwide thunderstorm activity, one would expect the characteristics of ELF atmospheric noise to vary considerably in different parts of the world. However, worldwide measurements indicate a similar spikiness in all the observed data. Even in relatively quiet parts of the world, spikes attributed to individual lightning strokes are evident, making the noise distinctly nongaussian.[1]

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*ELF (formerly called SANGUINE/SEAFARER) is an arbitrary designation applied to ongoing extremely low frequency research by the U. S. Navy. The term designates work directed toward the implementation of an ELF shore-to-ship radio communication system.

The nongaussian nature of the atmospheric noise has an important effect on receiver design and on system performance. With Gaussian noise, the optimum receiver is a linear processor whose performance can be determined by measuring the noise spectra. However, with nongaussian noise, the performance of a linear processor can be much worse than is suggested by the noise spectra. Furthermore, with an appropriate (nonlinear) processor, the performance can be much better than with Gaussian noise of the same spectral level.[1]

To optimize a communications receiver for operation in a nongaussian noise environment, it is desirable to place a controlled nonlinearity in the receiver at a stage of wide signal-plus-noise bandwidth to remove the high amplitude spikes. Evans and Griffith[1] conducted experiments with recorded ELF noise in an attempt to design and evaluate operationally feasible approximations to the optimum nonlinearity. They concluded that a simple clipper, adjusted adaptively to clip between 10 and 40 percent of the time, provides near-optimum performance. Therefore, the clipping levels in the AN/BSR-1 receiver are set up so that the data are clipped 40 percent of the time.

From August 1976 through December 1978, ELF field-strength and effective-noise* measurements were taken continuously in Connecticut and sporadically aboard operational submarines. This report summarizes the effective-noise measurements taken at both land (Connecticut) and sea locations during this period.

CONNECTICUT EFFECTIVE-NOISE MEASUREMENTS

For the Connecticut measurements, the AN/BSR-1 receiver is located at the Naval Underwater Systems Center (NUSC), in New London, CT, while the loop receiving antenna is located at Fisher's Island, NY (about 10 km from New London). The receiver and receiving antenna are connected by means of a microwave link from Fisher's Island to New London.

A summary of the 76-Hz effective-noise measurements taken in Connecticut from August 1976 to January 1977 has been presented in an earlier report.[2] In this report, we will extend those results by presenting the amplitude probability distributions (APD's) for the effective-noise data taken in Connecticut from August 1976 through December 1978.

The average monthly APD's for January through December are compared in figure 1,† while the APD's for the individual months are presented in the appendix. Also presented in figure 1 is the APD for the noisiest period of the year in Connecticut (2000 to 2400 Greenwich Mean Time (GMT) during July).

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*The effective-noise spectrum level (in dBA/m$\cdot\sqrt{1\ \text{Hz}}$) is defined as the spectrum level of ELF noise at the signal frequency divided by the improvement (in signal-to-noise ratio (SNR)) using nonlinear processing.[1]

†All figures have been placed together at the end of this report or in the appendix.

From these figures, we can see that, over most of the range, the distribution curves are essentially straight lines on probability paper. That is, the effective-noise level (in dBH) has a normal (or Gaussian) distributi.n. The slope of the distribution lines determines the standard deviation of the log-normal distribution. Specifically, the standard deviation (in dB) is one-half the difference between the 16- and 84-percent levels. An observation of figure 1 reveals that the standard deviation ranges from approximately 1.5 dB (January) to approximately 4 dB (July).

The 1- to 90-percent exceedance levels for the various months of the year are tabulated in table 1 and plotted in figure 2, while typical Connecticut effective-noise diurnal variations during May, July, October, and December are illustrated in figure 3. From these figures, we see that there are definite midlatitude seasonal and diurnal variations in ELF effective-noise levels. As expected, the effective-noise level, as well as the diurnal variation, is much higher in the summer than in the winter. The difference in effective-noise levels for each month between January and July/August is approximately 11 dB (50-percent exceedance level), 13 dB (20-percent exceedance level), 15 dB (10-percent exceedance level), 16 dB (5-percent exceedance level), and 18 dB (1-percent exceedance level), respectively.

Table 1. 1976 to 1978 Connecticut Average Effective-Noise Distributions

Month	Exceedance Levels					
	1 Percent	5 Percent	10 Percent	20 Percent	50 Percent	90 Percent
January	-142.0	-143.1	-143.7	-144.4	-145.5	-147.2
February	-139.0	-140.6	-141.2	-142.2	-143.8	-146.3
March	-137.3	-138.4	-139.0	-140.0	-141.5	-143.6
April	-134.8	-136.9	-137.9	-139.0	-140.9	-143.2
May	-130.4	-132.8	-134.0	-135.6	-138.3	-142.0
June	-125.6	-129.6	-131.5	-133.6	-136.8	-140.5
July	-124.4	-126.8	-129.0	-131.3	-134.8	-139.1
August	-126.0	-128.4	-129.9	-131.8	-134.7	-138.6
September	-130.4	-132.2	-133.2	-134.4	-136.6	-139.7
October	-133.2	-135.0	-136.0	-137.1	-139.1	-142.3
November	-135.4	-137.1	-137.9	-139.0	-141.0	-143.6
December	-138.8	-140.4	-141.4	-142.4	-144.0	-146.8
Spread (dB)	17.6	16.3	14.7	13.1	10.8	8.6

We know that most of the effective-noise data taken during the winter months, as well as the 80- to 99-percent exceedance levels for the other months of the year, are contaminated by industrial noise at the Fisher's Island, NY, receiving site. Effective-noise values less than -145 dBH, which are often measured at sea, are very rarely measured in Connecticut.

As a further example of the contamination of the Connecticut effective noise (at the low end), consider figure 4, which is a comparison of the 2 November 1978 Connecticut and South-Atlantic equatorial-area effective noise. From this figure, we see that the South-Atlantic equatorial-area diurnal variation was 23 dB (-140 to -163 dBH), while the Connecticut diurnal variation was only 7 dB (-138 to -145 dBH). While the maximum values (-138 to -140 dBH), were similar at both locations, the minimum values were grossly different. From 0000 to 0430, the equatorial-area effective noise decreased from -150 to -163 dBH (the lowest value of 76-Hz effective noise measured anywhere to date). The effective noise then increased to -144 dBH by 1200. During this same time period, the (contaminated) Connecticut effective noise remained essentially constant (~-144.5 dBH).

As we mentioned previously, the noisiest period of the year in Connecticut is from 2000 to 2400 during July (just before local sunset). A comparison of the effective noise measured during this very noisy time period with the noise measured during one of the quietest time periods (0000 to 1000 GMT, October/November 1978, South-Atlantic equatorial area) is presented in figure 5. We see that although the slope of each APD is similar, the effective-noise levels are 20 to 23 dB different in magnitude.

The extremely high (>-130 dBH) Connecticut summertime effective-noise levels are very repeatable from one year to the next (see appendix). Effective-noise values greater than -129 dBH have never been measured anywhere else but in Connecticut. Unfortunately, no effective-noise measurements have been taken at sea during the high-noise (2000 to 2400 GMT) period in July. However, in late June 1978, four days of signal-strength and effective-noise measurements were taken on a submarine located off the Florida coast. The Connecticut and Florida-area effective-noise APD's for these four days were nearly identical and will be discussed in more detail later. A comparison of the 19 to 20 June 1978 Connecticut and Florida-area effective noise is presented in figure 6. Note that the diurnal plots are very similar for both east-coast locations, both in absolute levels and times of occurrence. The Connecticut effective noise varied from -127 to -138 dBH (11 dB), while the Florida-area effective noise varied from -129 to -140 dBH (also 11 dB).

OPERATIONAL-SUBMARINE EFFECTIVE-NOISE MEASUREMENTS

Since September 1976, 76-Hz effective-noise measurements have been taken sporadically aboard operational submarines. In this section, we will present APDs for some of these data and compare them with data taken in Greece[3] and Saipan.[3] Monthly comparisons of Connecticut and operational-submarine effective-noise APD's will be presented in the next section. For further details on signal strengths (both amplitude and relative phase), effective noise, and SNR's measured aboard operational submarines, see earlier reports.[4-8]

It should be noted that all of the submarine effective-noise data presented in this report are contaminated to some degree by submarine-generated noise (external or internal to the submarine). Thus, the values presented here are on the high side.

Presented in figure 7 is a summary of some of the North-Atlantic-area submarine effective-noise APD's. Note that the distributions for the six different months are very similar and differ from each other by only 1 to 4 dB. Also, note that, with the exception of the September 1976 measurements, they are all slightly lower (from the 1- to 50-percent exceedance levels) than the May 1972 Greece effective-noise values.[3] In this figure and many to follow, N is the number of 15-min noise samples taken for a particular time period.

The North-Atlantic-area average effective-noise diurnal variations during four different months are presented in figure 8. Note that, during January, the average diurnal variation was only about 2 dB, while during March, August, and October the average diurnal variation was 6 to 8 dB.

A summary of the limited amount of Pacific-area effective-noise APD's is presented in figure 9. The most reliable Pacific data (taken over 26 days) are the October data, which are 1 to 4 dB lower than the May 1972 Saipan effective noise.[3] The March Hawaii-area data represents measurements over only 4-1/2 days. (There are 96 fifteen-minute samples per day.)

The Pacific-area October effective-noise average diurnal variations are presented in figure 10, while the South-Atlantic equatorial-area October/November average effective-noise diurnal variations are presented in figure 11. The average diurnal variation was ~6 dB in the Western Pacific and ~12 dB in the South-Atlantic equatorial area.

MONTHLY COMPARISONS OF CONNECTICUT AND OPERATIONAL-SUBMARINE EFFECTIVE-NOISE MEASUREMENTS

A comparison of the Connecticut and North-Atlantic-area submarine effective-noise APD's for January is presented in figure 12. The 1977 and 1978 North-Atlantic-area noise distributions are within 2 dB of each other, and the 1- to 60-percent exceedance-level Connecticut noise was the lowest. It should be noted that the January 1977 Connecticut and submarine data were taken on different days.

Presented in figure 13 is a comparison of the Connecticut and submarine effective-noise APD's for February. Here, we see that, during 1978, the Connecticut and North-Atlantic-area noise distributions were almost carbon copies of each other, while the (contaminated) 1977 Connecticut noise was 1 to 4 dB higher.

A comparison of the Connecticut and submarine APD's for March is presented in figure 14. Again, the Connecticut and North-Atlantic-area noise distributions are quite similar. On the other hand, the Hawaii-area APD (which is for data on only 4-1/2 days) is remarkably different.

Presented in figure 15 is a comparison of the Connecticut and Greenland-Sea-area effective-noise APD's for April. Here, we see that, for the 1- to 80-percent exceedance levels, the 1977 noise distributions are very similar, with the Connecticut noise slightly higher.

A comparison of the Connecticut and Florida-area submarine effective-noise APD's for four days in late June 1978 is presented in figure 16. Note that, for the 10- to 70-percent exceedance levels, the two noise distributions are almost carbon copies of each other. The effective noise is also 5 to 7 dB higher than that measured at Greece and Saipan during May 1972.[3]

Presented in figure 17 is a comparison of the Connecticut and Norwegian-Sea-area effective-noise APD's for August 1978. We see that the Connecticut effective noise is substantially higher, varying from 6 dB higher at the 50- to 99-percent exceedance levels to approximately 12 dB higher at the 1-percent exceedance level.

Comparisons of the Connecticut and North-Atlantic-area effective-noise APD's for September and October 1976 are presented in figures 18 and 19. Here, we see that, although the slopes of the Connecticut and North-Atlantic-area APD's are similar, the Connecticut effective-noise values are 3 to 5 dB higher.

Presented in figure 20 is a comparison of the Connecticut, Pacific-area, and North-Atlantic-area APD's for October 1977. The early October North-Atlantic and Western-Pacific noise distributions are quite similar, with the North-Atlantic noise levels slightly higher. The lowest (1- to 80-percent exceedance level) effective noise was measured in the Northwest Pacific during late October, while the highest (by 3 to 8 dB) again was measured in Connecticut.

A comparison of the Connecticut, Virgin-Islands-area, and North- and South-Atlantic equatorial-area effective-noise APD's for October 1978 is presented in figure 21. We see that there are considerable differences in effective-noise values measured in different areas, with the differences varying from 3 dB at the 1-percent exceedance level to 8 dB at the 90-percent exceedance level. The highest effective noise was measured in the Virgin-Islands area, while the lowest effective noise was measured in the South-Atlantic equatorial area.

Presented in figure 22 is a comparison of the November 1978 Connecticut, Virgin-Islands-area, and North- and South-Atlantic equatorial area effective-noise APD's. Note that the Connecticut noise was considerably higher (by 7 to 9 dB) than the late November Virgin-Islands effective noise, while during early October, the Connecticut noise was 1 to 2 dB lower (figure 21). The lowest November effective noise was measured in the South-Atlantic equatorial area during early November and in the Virgin-Islands area during late November. Note that for the 40- to 95-percent exceedance levels, these two noise distributions are almost carbon copies of each other.

CONCLUSIONS

This report summarizes the 1976 to 1978 ELF effective-noise measurements taken continuously in Connecticut and sporadically aboard operational submarines. The main conclusion is that there are often considerable differences in effective-noise levels measured at land (Connecticut) and sea locations. The highest effective-noise levels were measured in Connecticut during the summer months, while the lowest effective-noise levels were measured in the South-Atlantic equatorial area during November.

Most of the Connecticut (low-level) effective-noise data taken during the winter months, as well as the 80- to 99-percent exceedance levels for the other months of the year, are contaminated by industrial noise at the Fisher's Island, NY, receiving location. All of the submarine effective-noise data are also contaminated to some degree by submarine-generated noise (external or internal to the submarine).

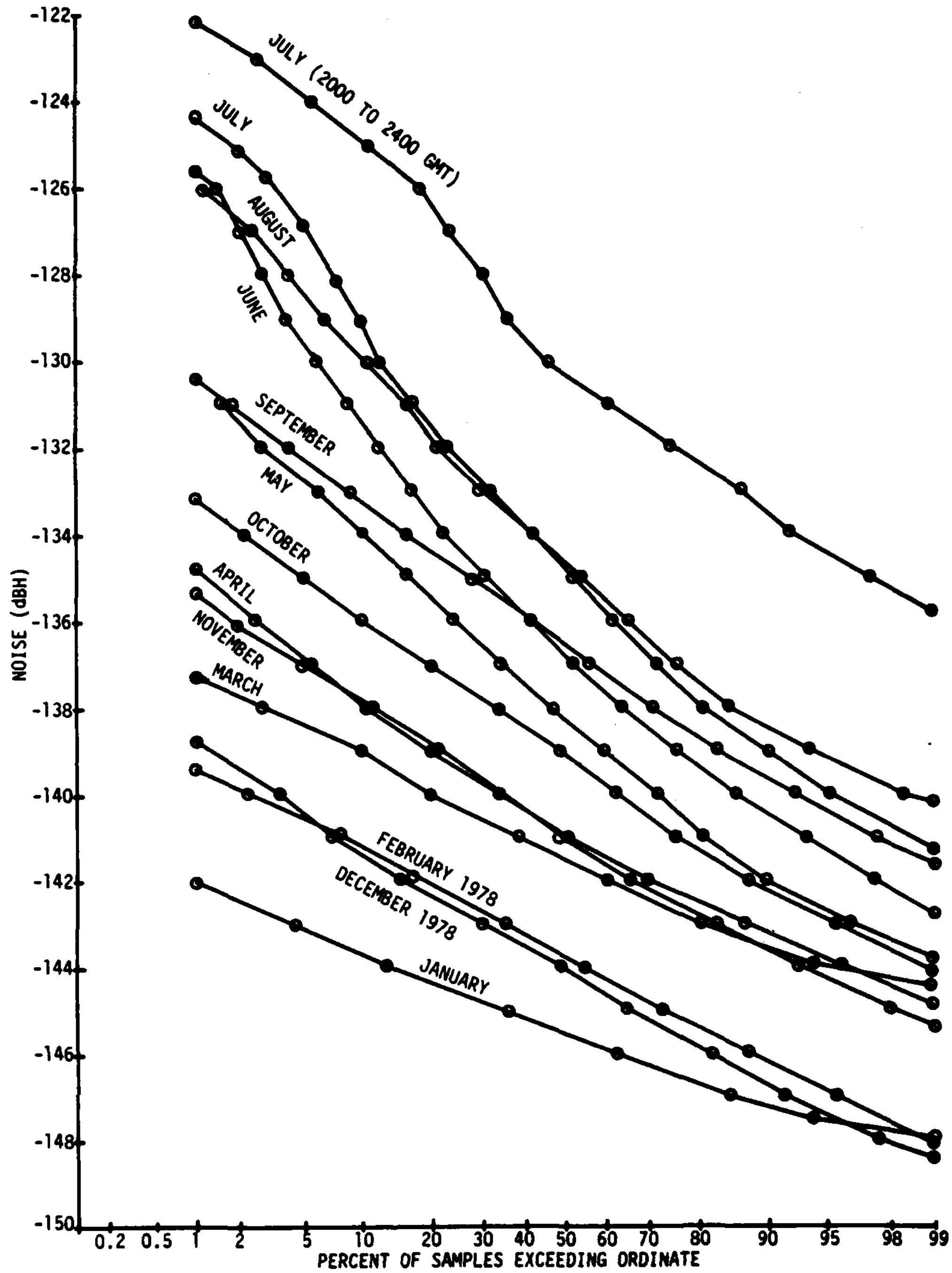

Figure 1. Connecticut Monthly Average Effective-Noise APD's, 1976 to 1978

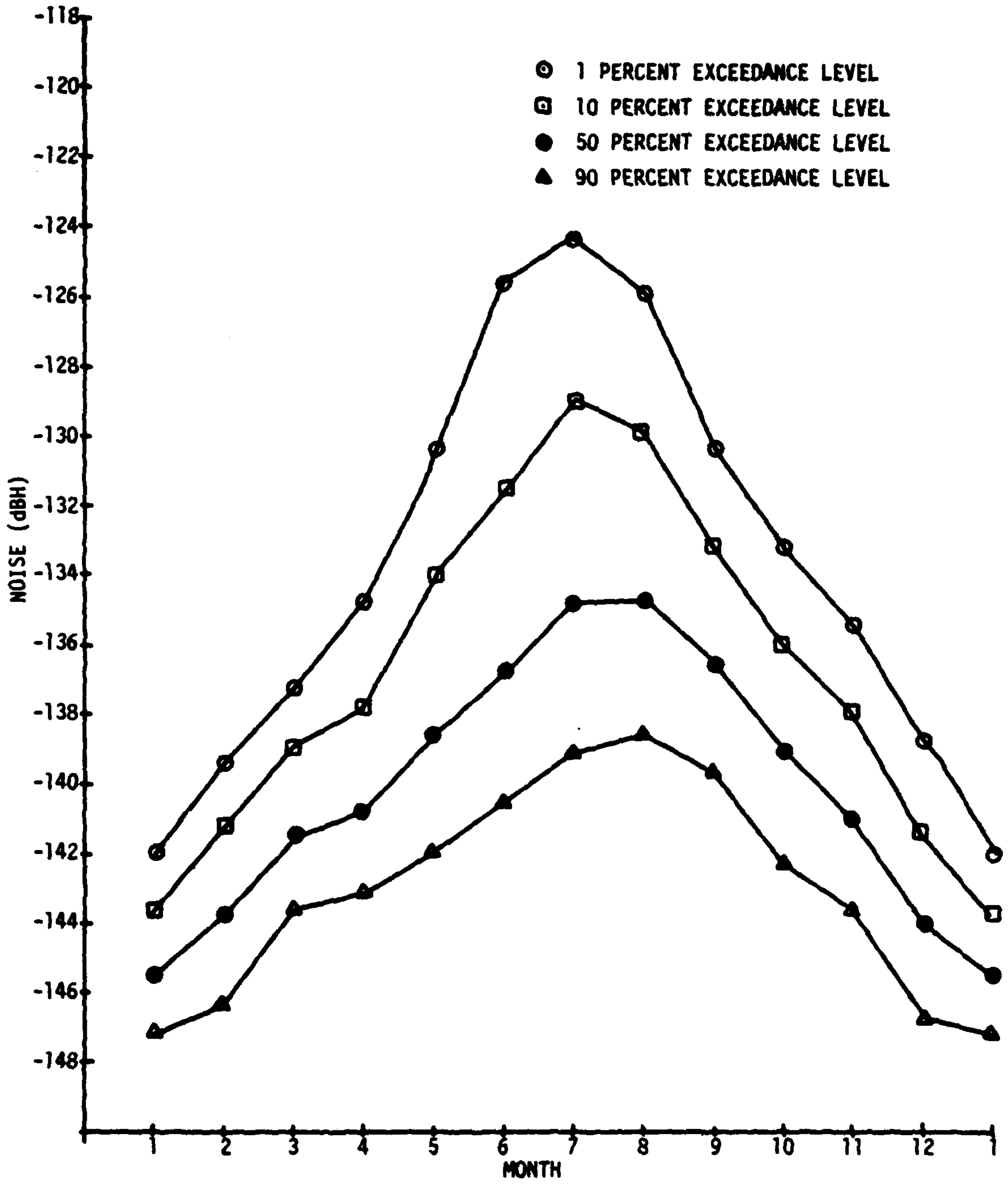

Figure 2. Connecticut Average Effective-Noise Levels Versus Month

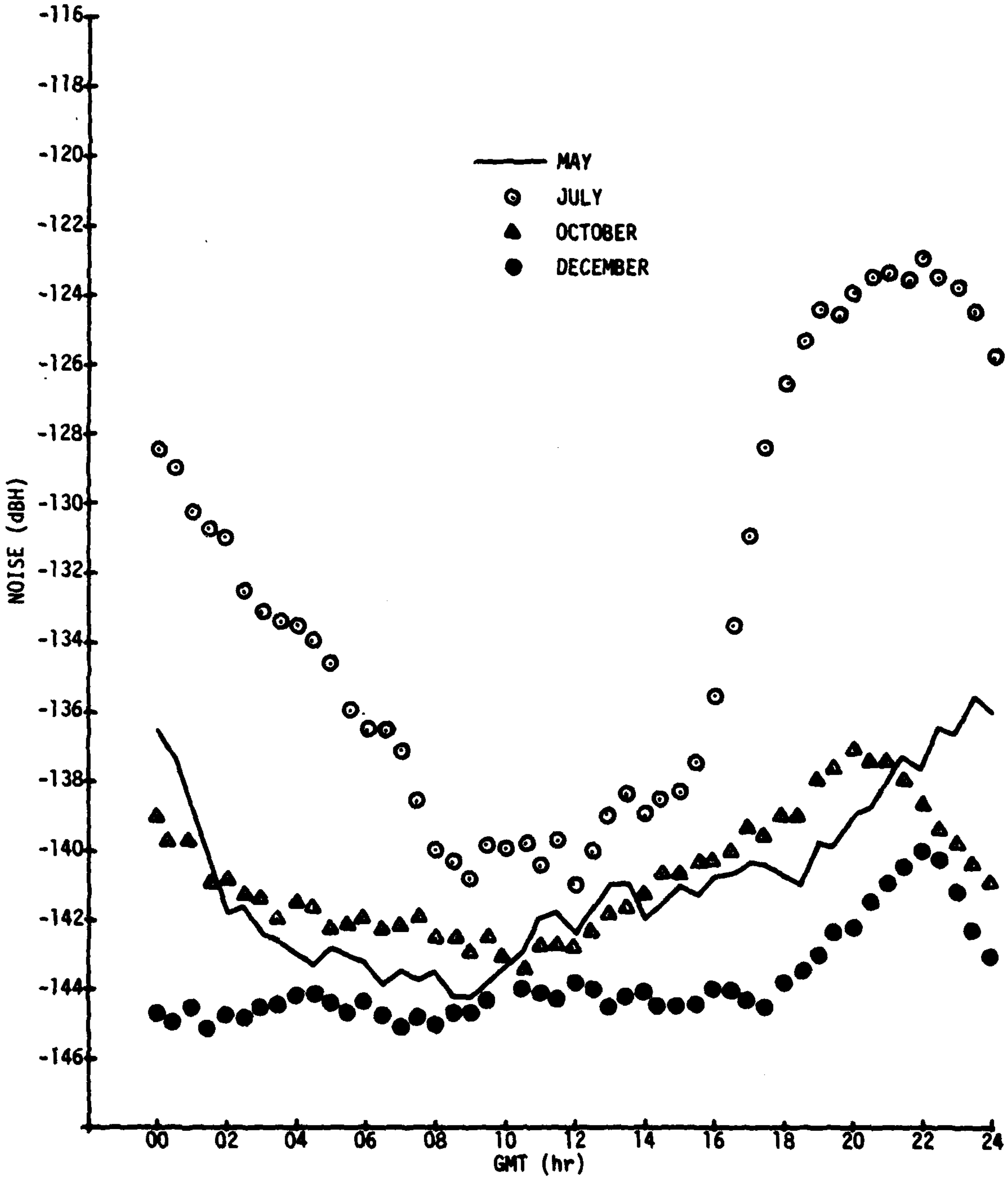

Figure 3. Typical Connecticut Effective-Noise Diurnal Variations

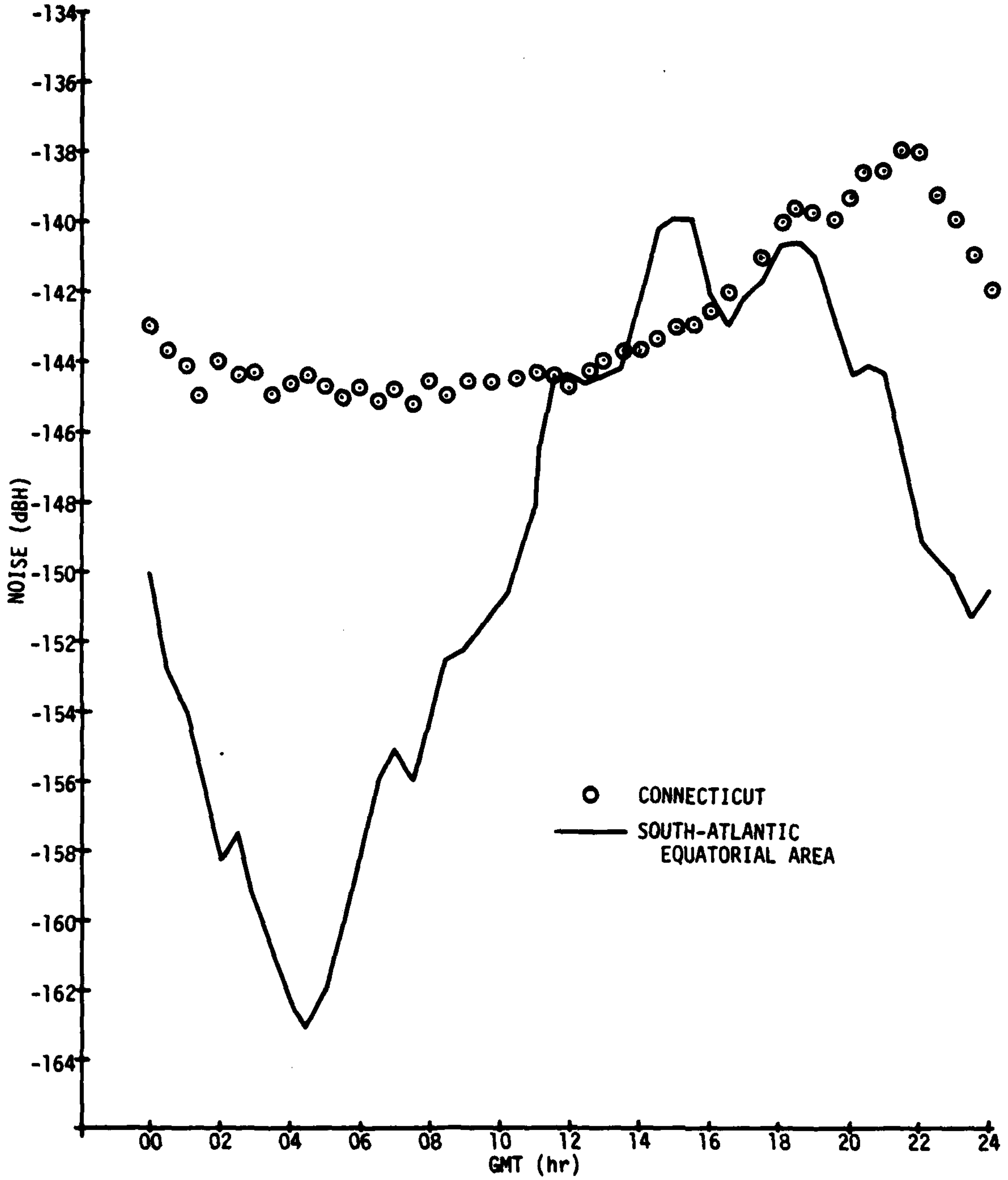

Figure 4. Comparison of Connecticut and South-Atlantic-Area Effective Noise, 2 November 1978

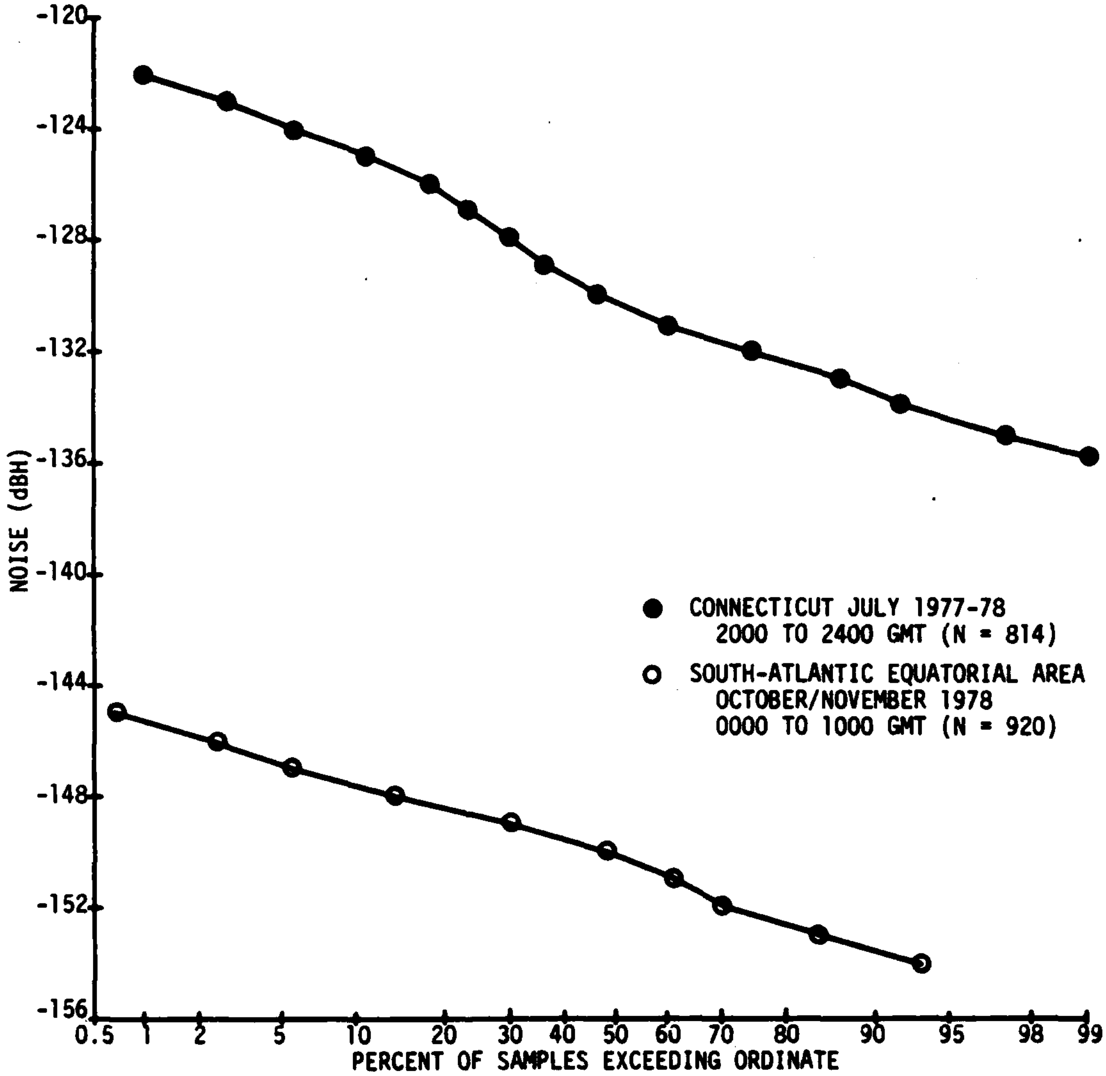

Figure 5. Comparison of 2000 to 2400 GMT July Connecticut and 0000 to 1000 GMT October/November South-Atlantic Equatorial-Area Effective-Noise APD's

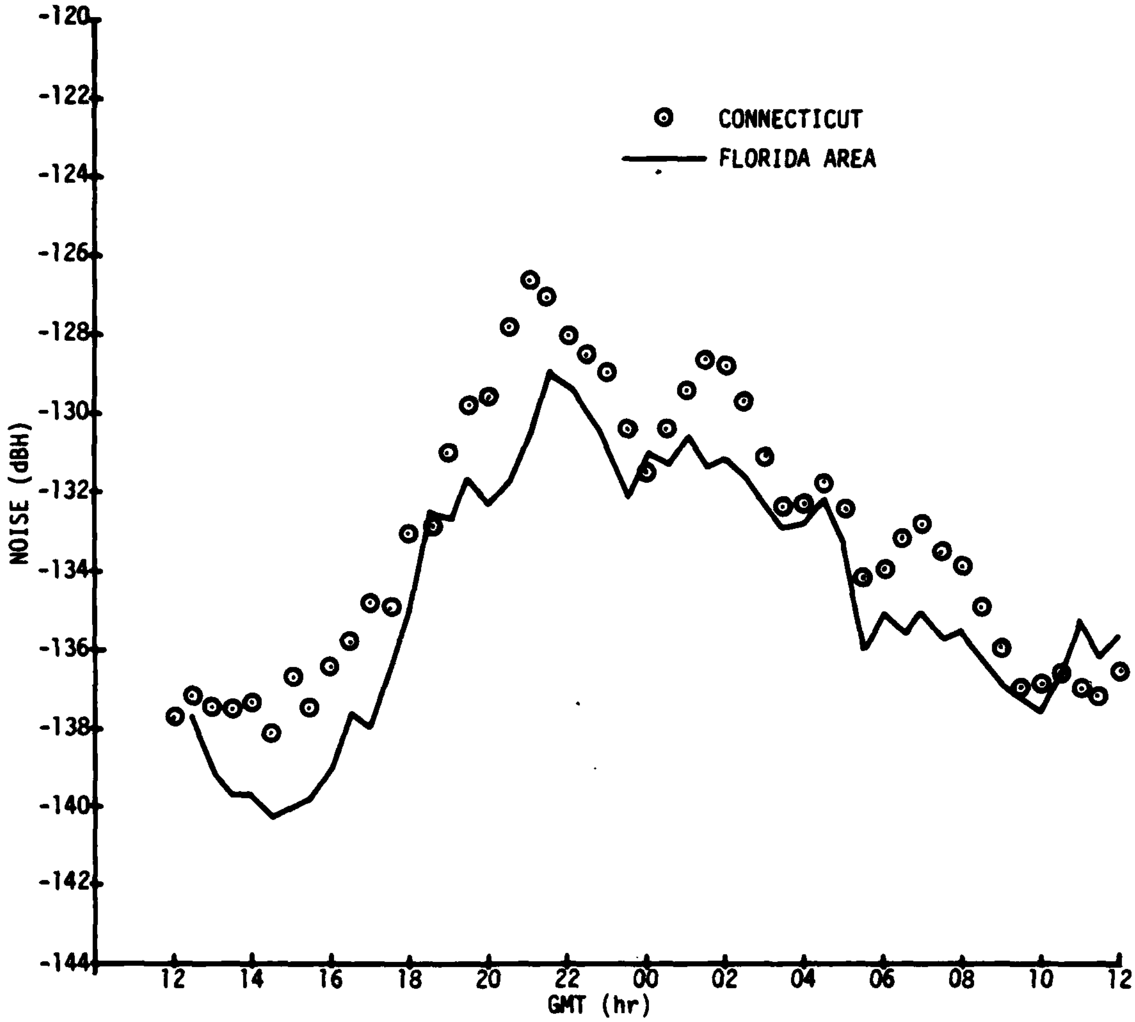

Figure 6. Comparison of Connecticut and Florida-Area Effective Noise, 19 to 20 June 1978

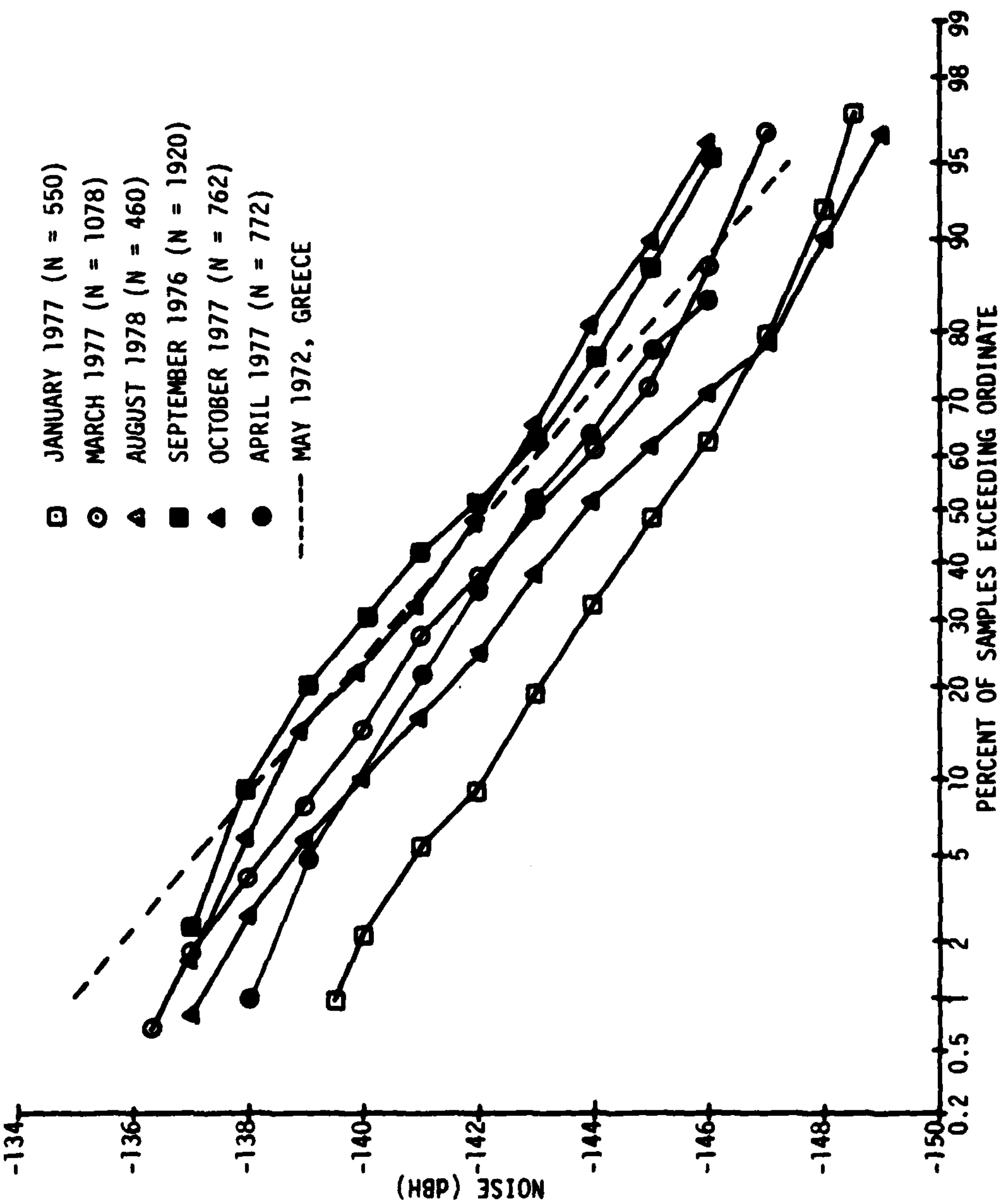

Figure 7. Comparison of North-Atlantic-Area Effective-Noise APD's

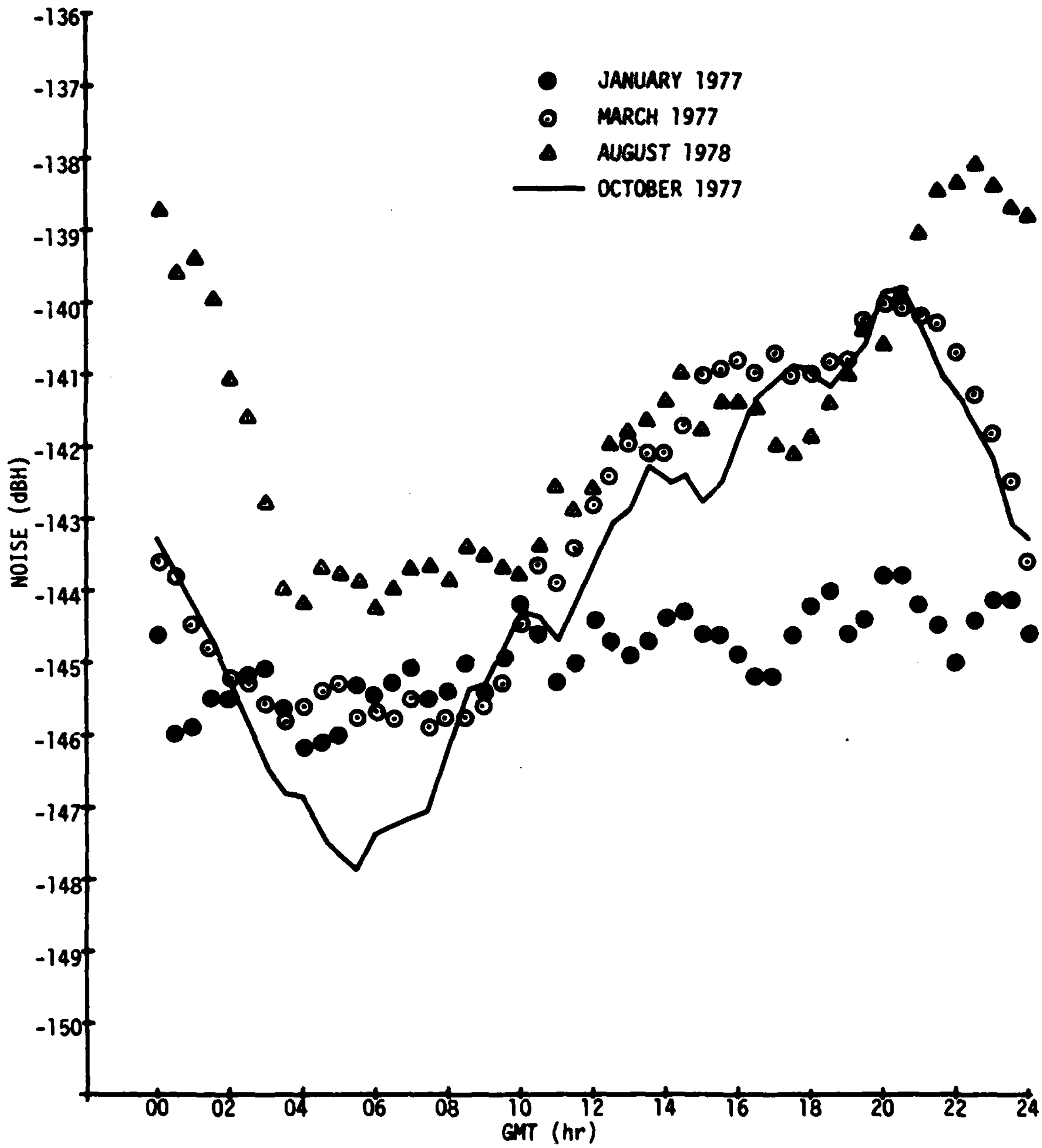

Figure 8. Average North-Atlantic-Area Effective-Noise Diurnal Variations

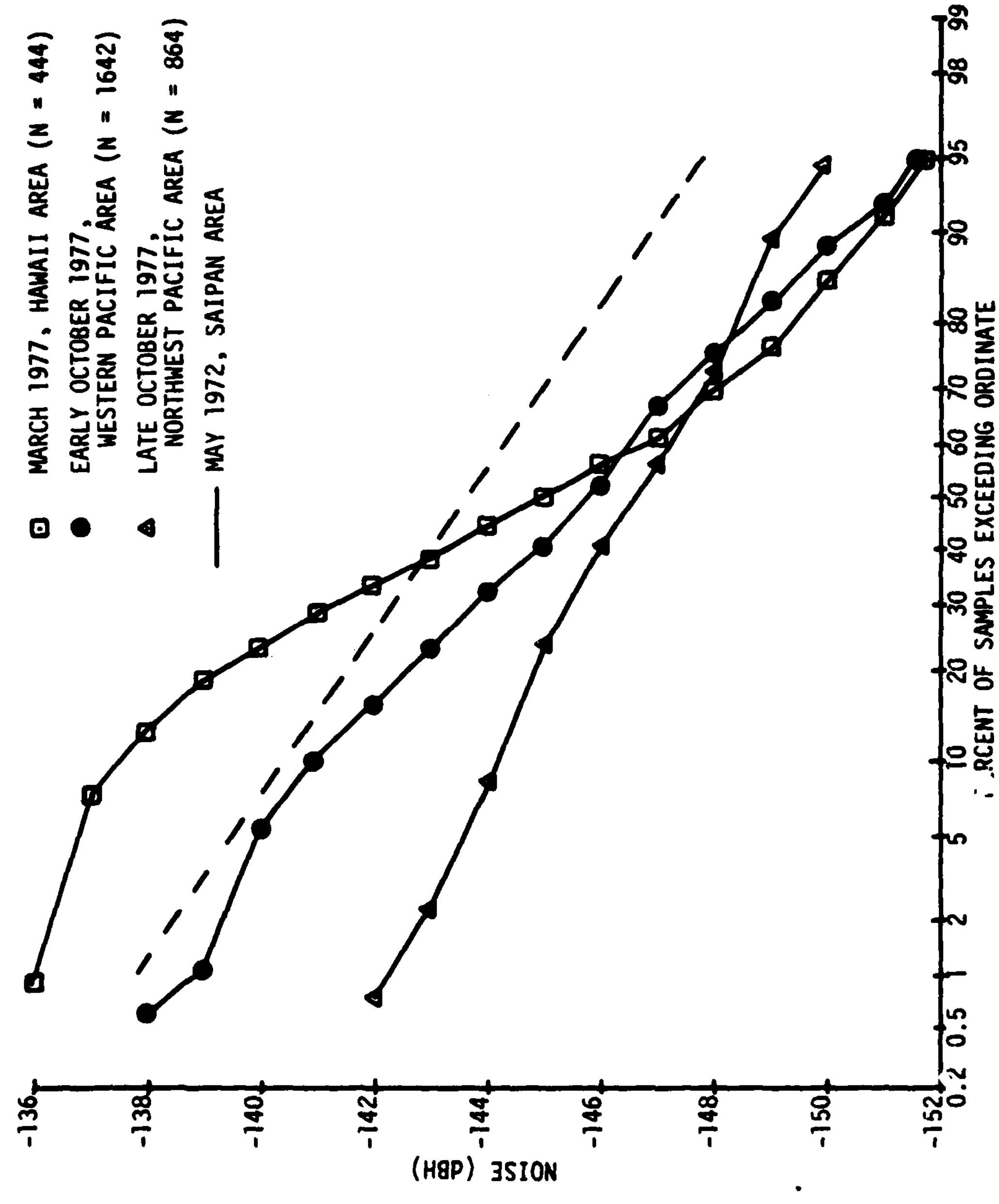

Figure 9. Comparison of Pacific-Area Effective-Noise APD's

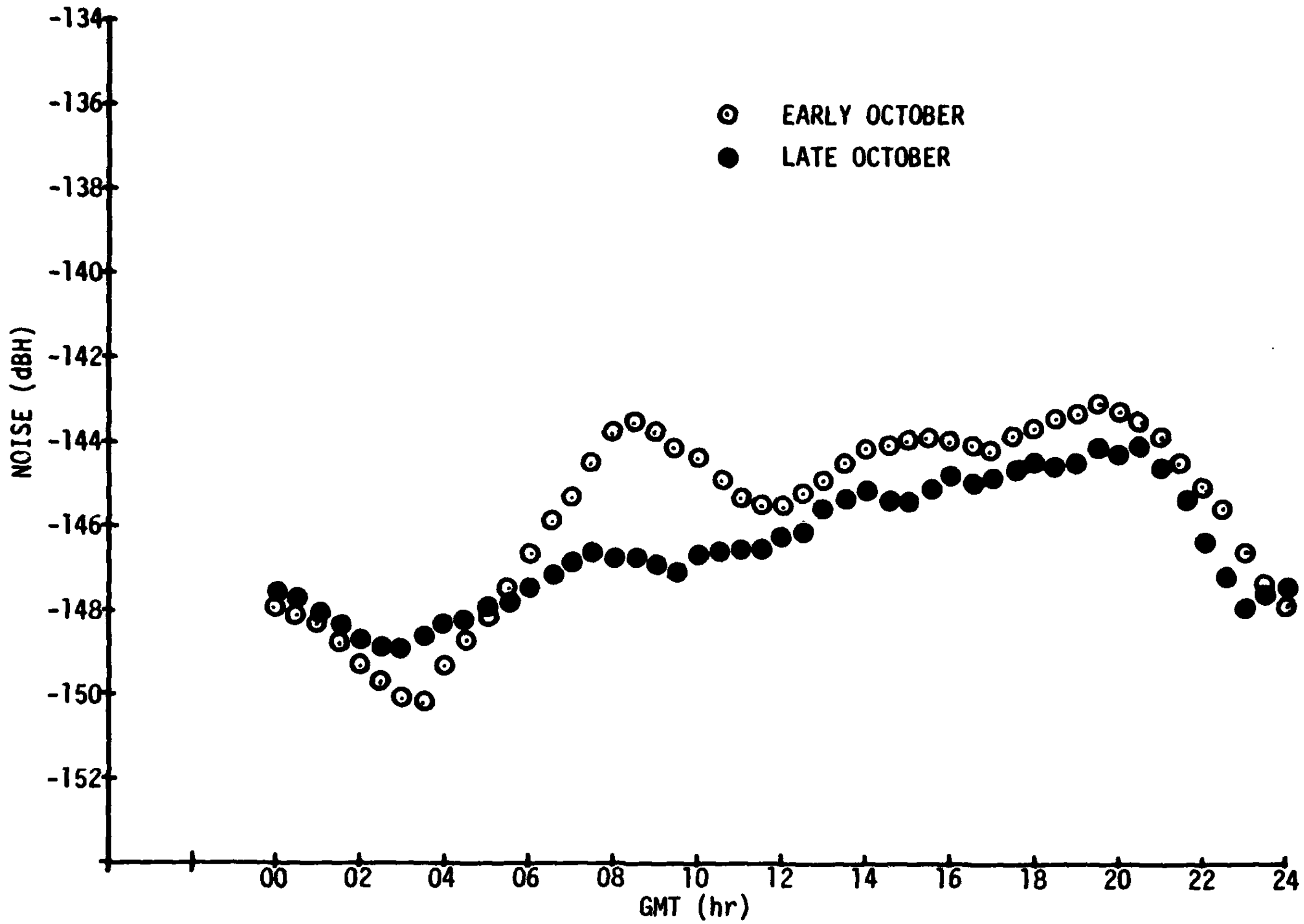

Figure 10. October Average Pacific-Area Effective-Noise Diurnal Variations

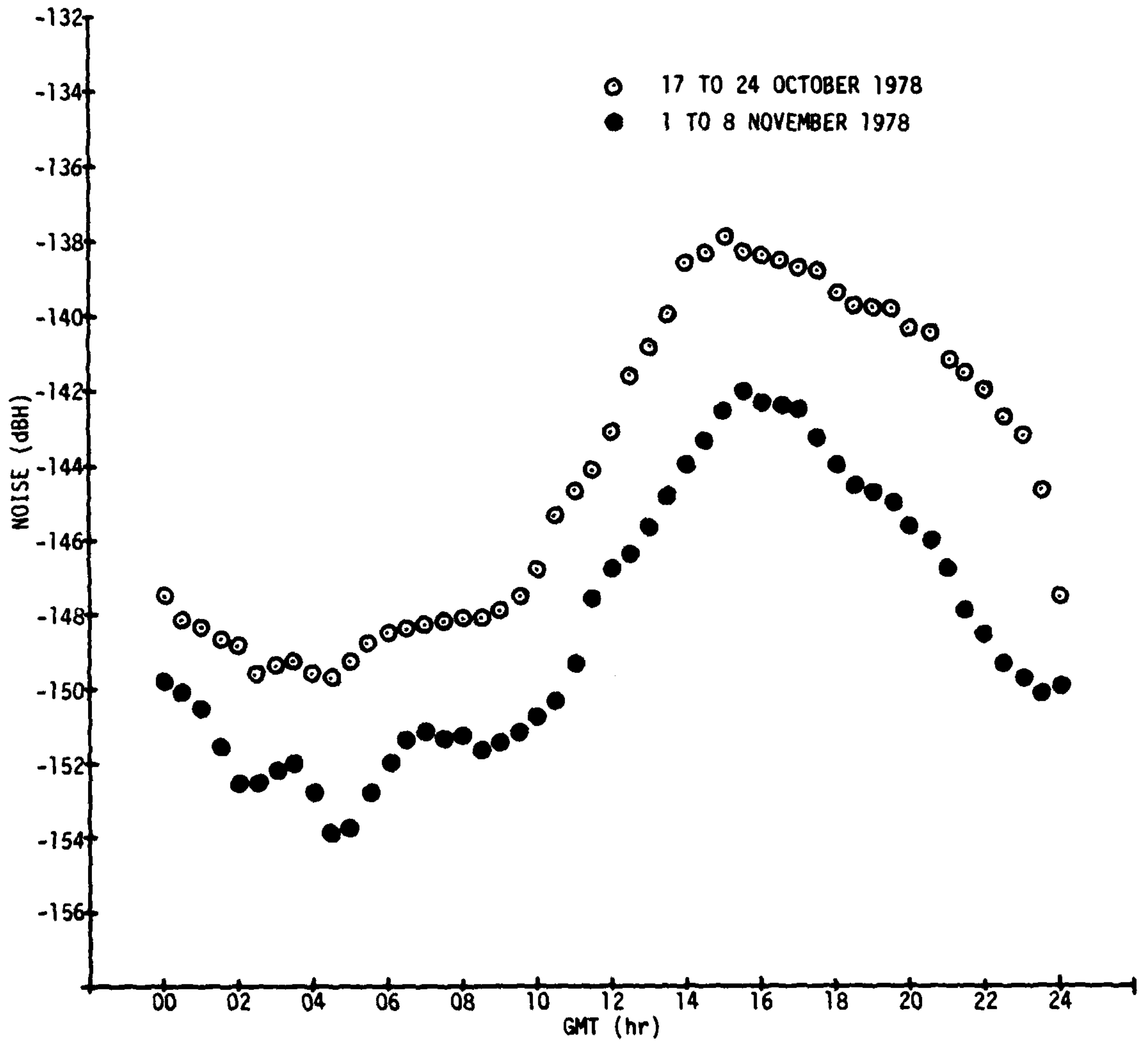

Figure 11. October/November Average South-Atlantic Equatorial-Area Effective-Noise Diurnal Variations

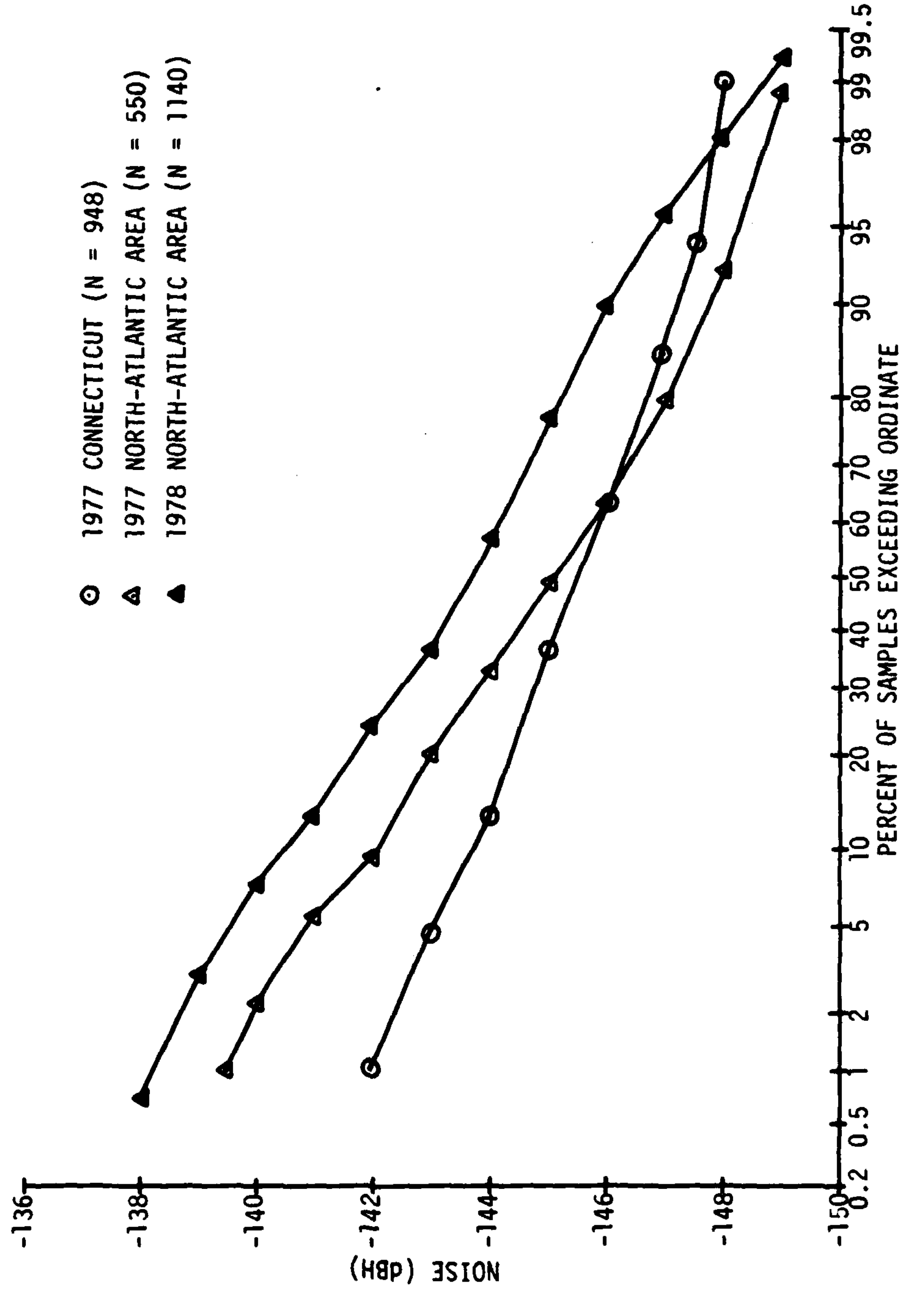

Figure 12. Comparison of January Effective-Noise APD's

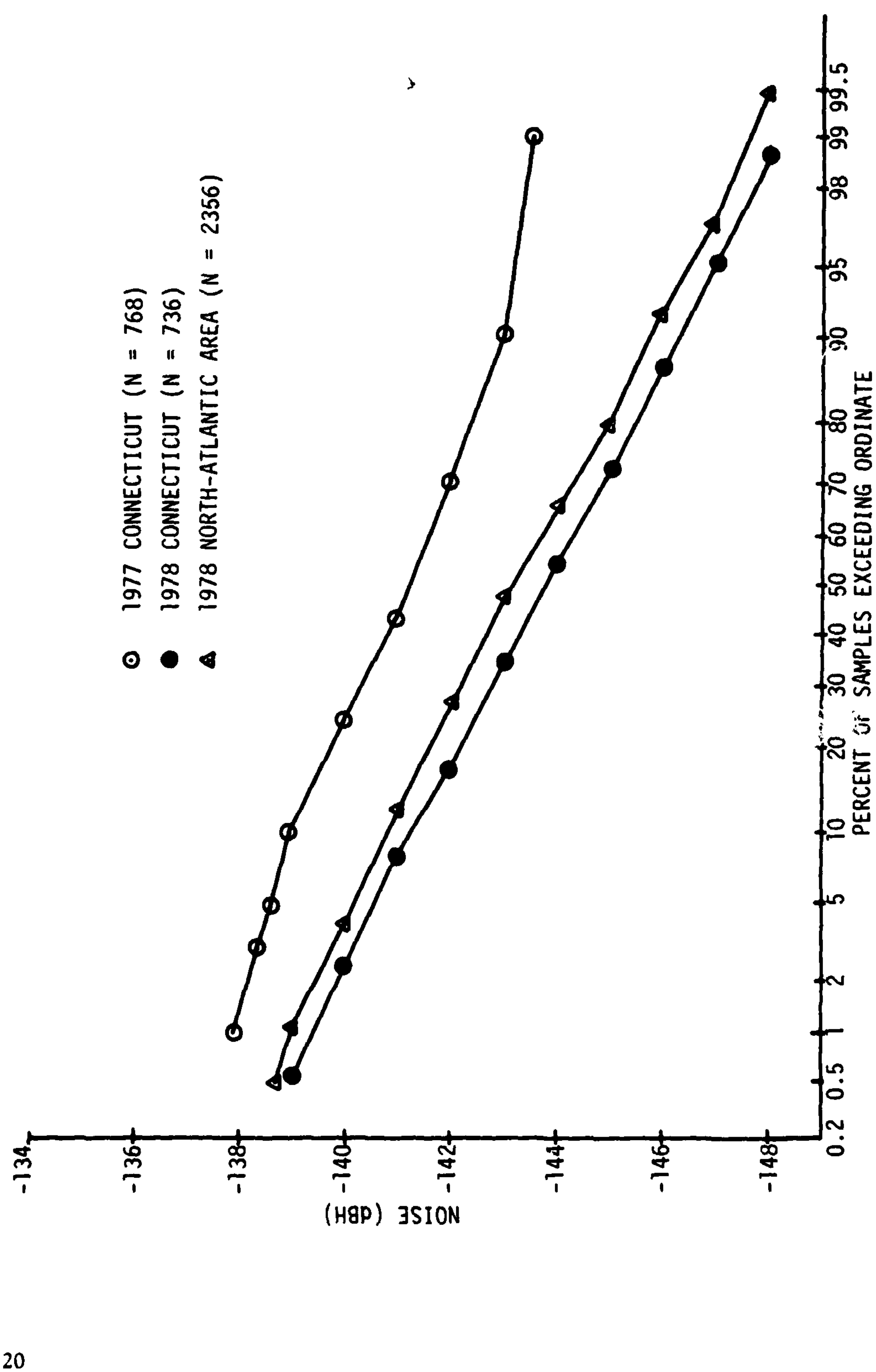

Figure 13. Comparison of February Effective-Noise APD's

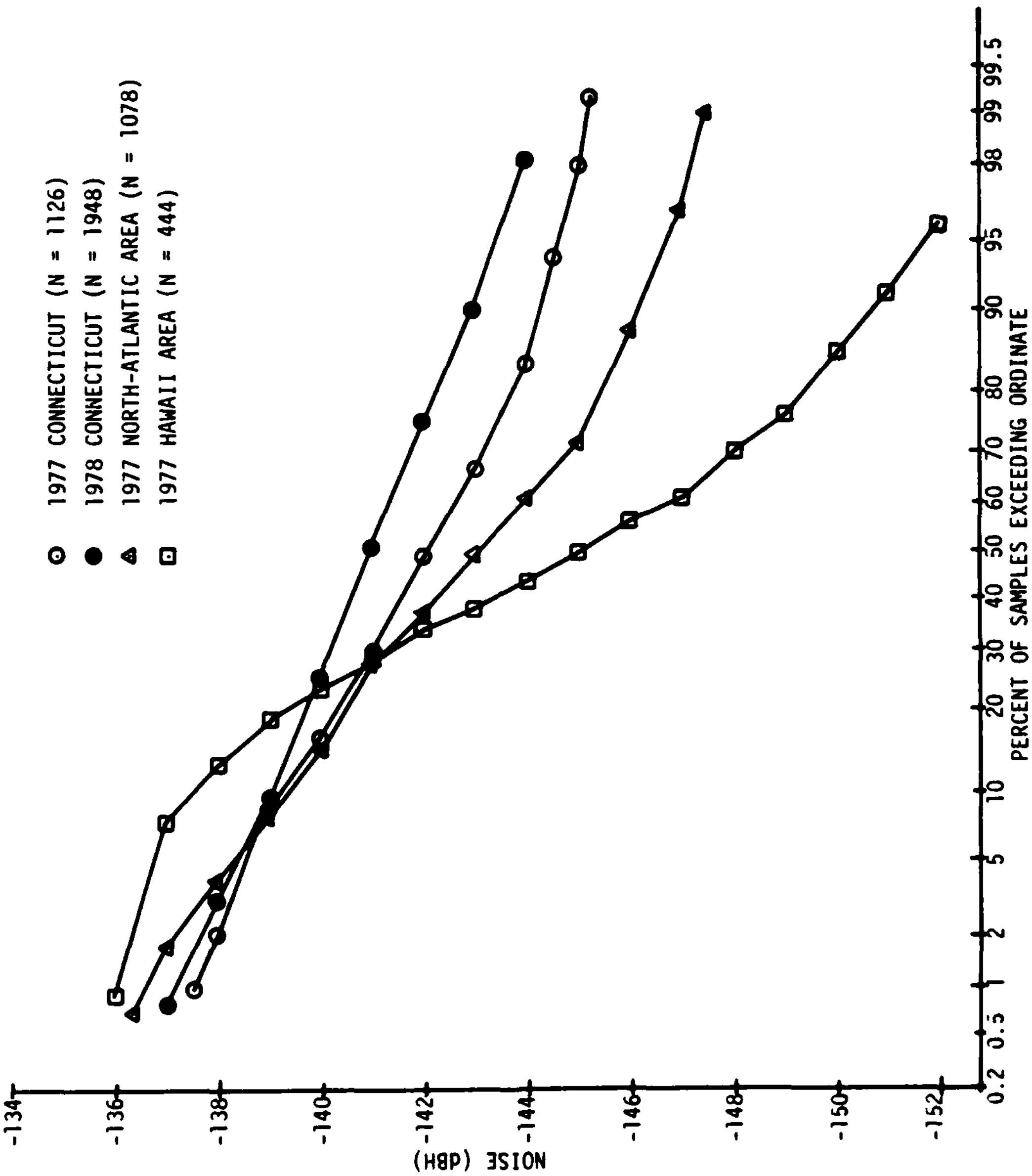

Figure 14. Comparison of March Effective-Noise APD's

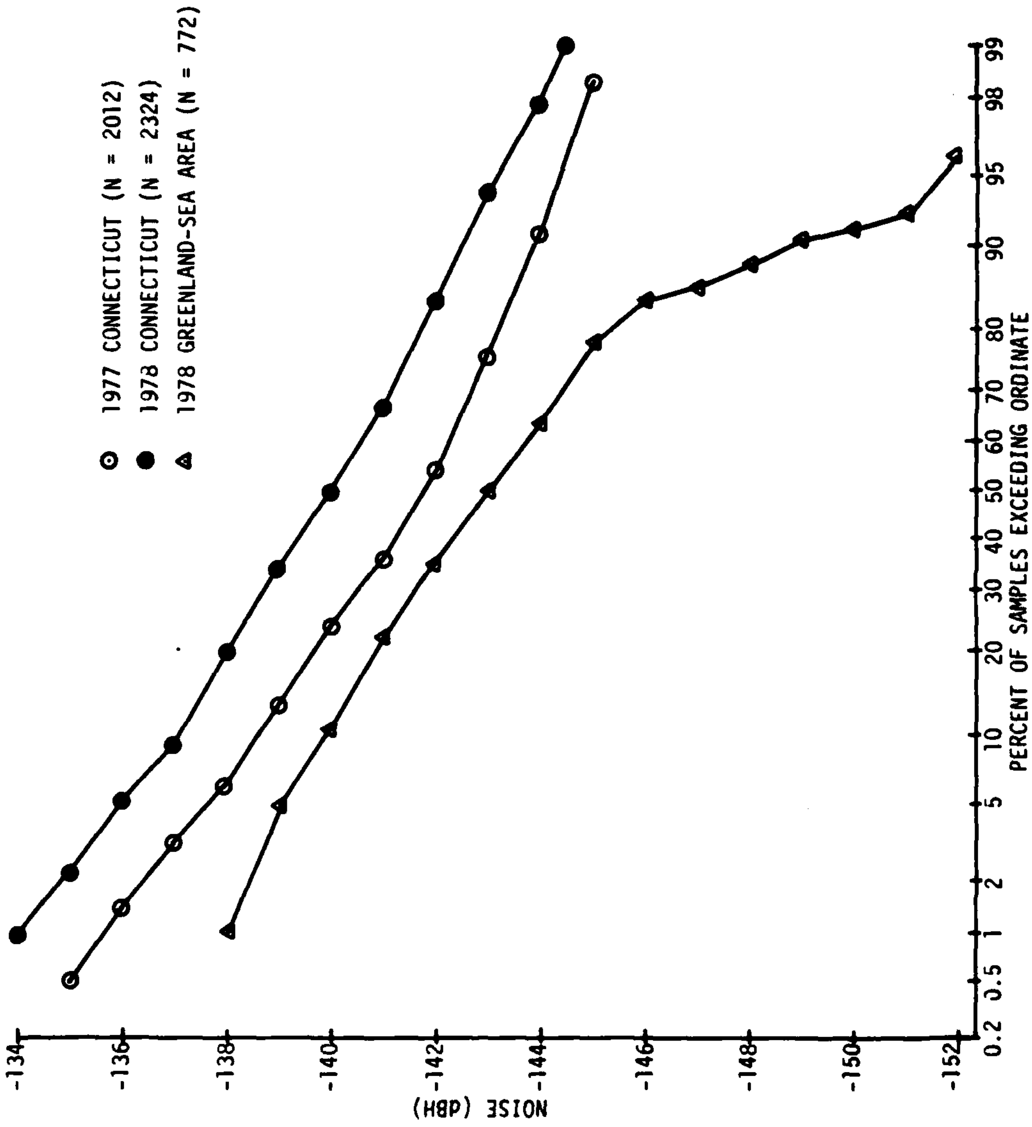

Figure 15. Comparison of April Effective-Noise APD's

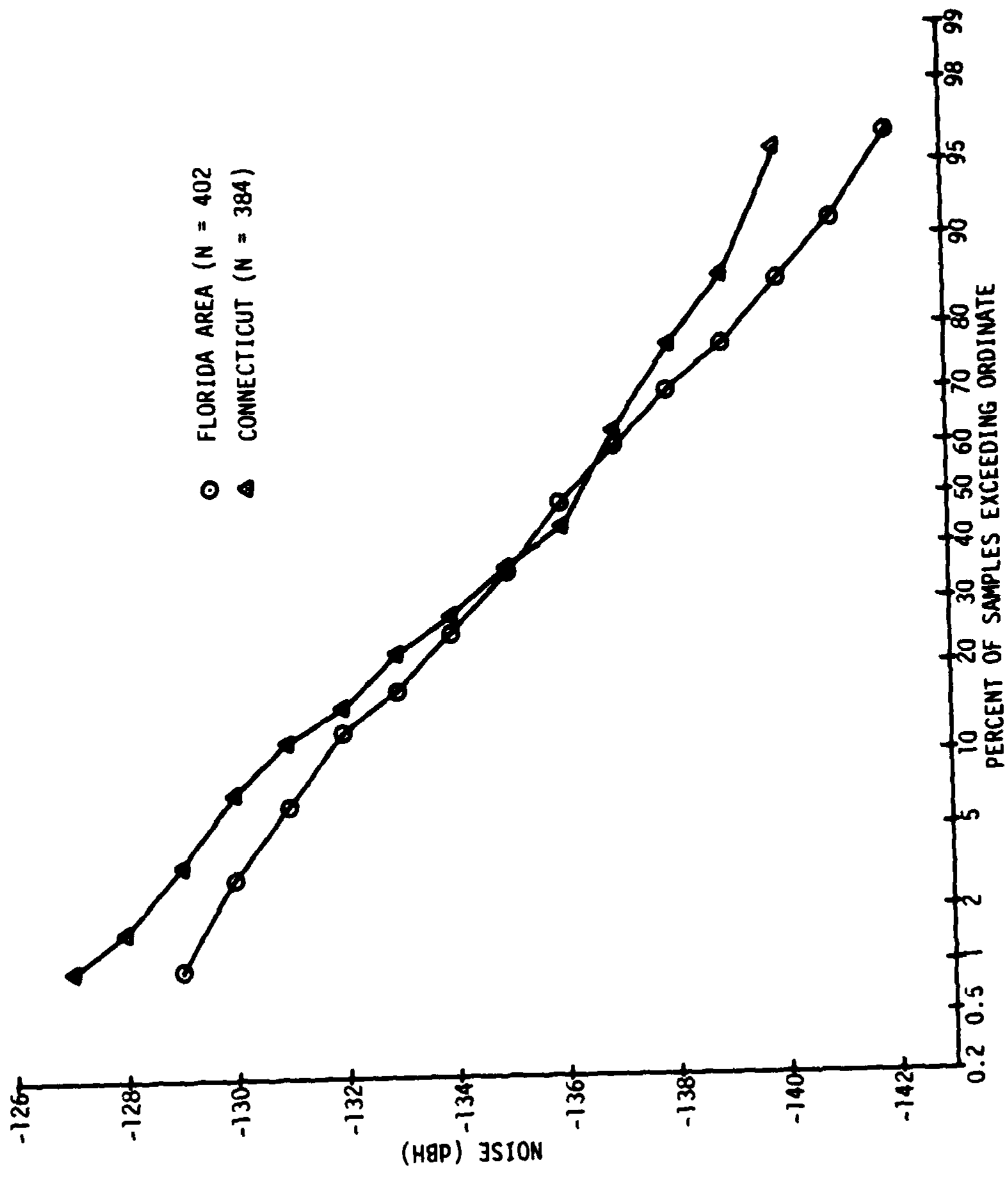

Figure 16. Comparison of June 1978 Effective-Noise APD's

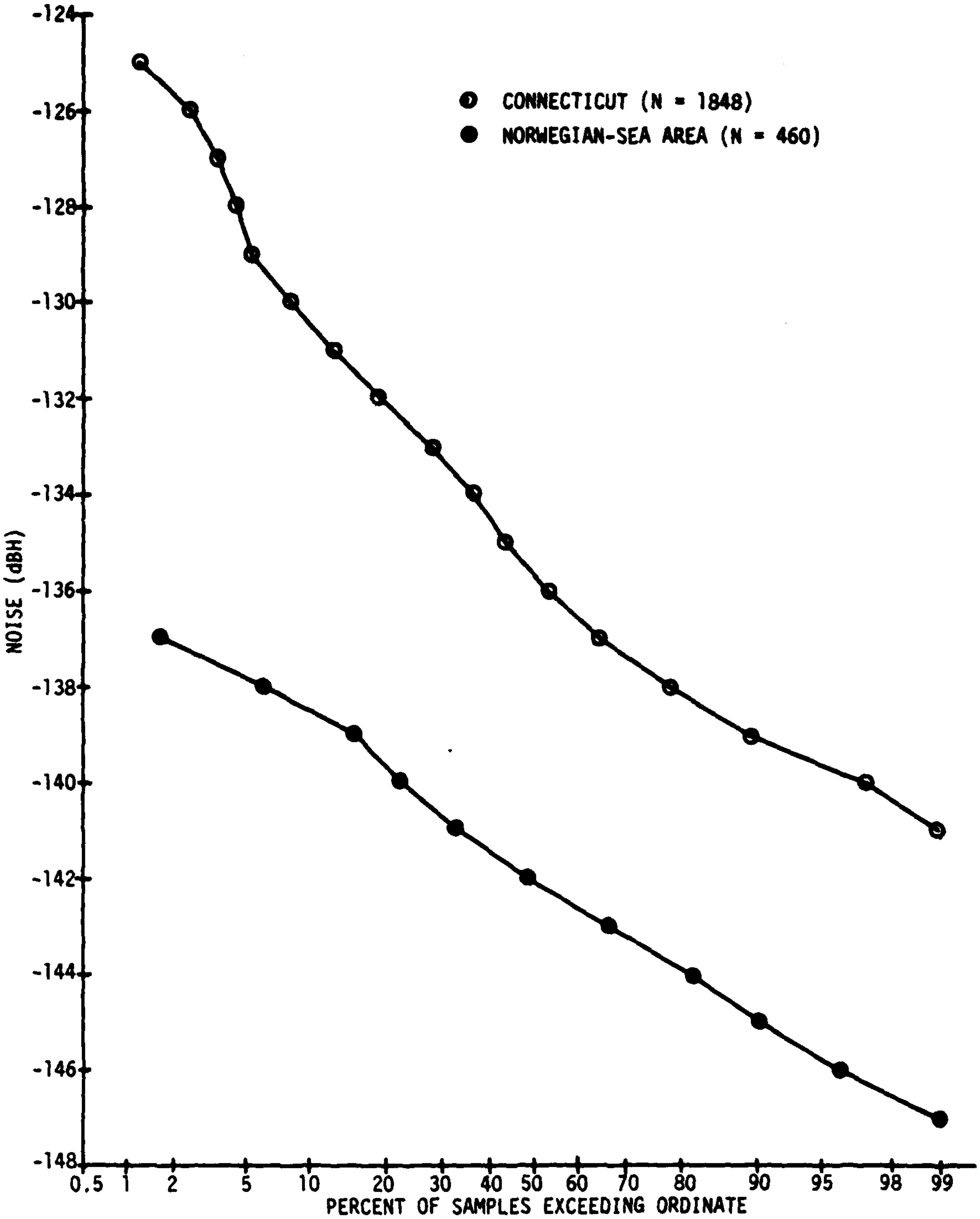

Figure 17. Comparison of August 1978 Effective-Noise APD's

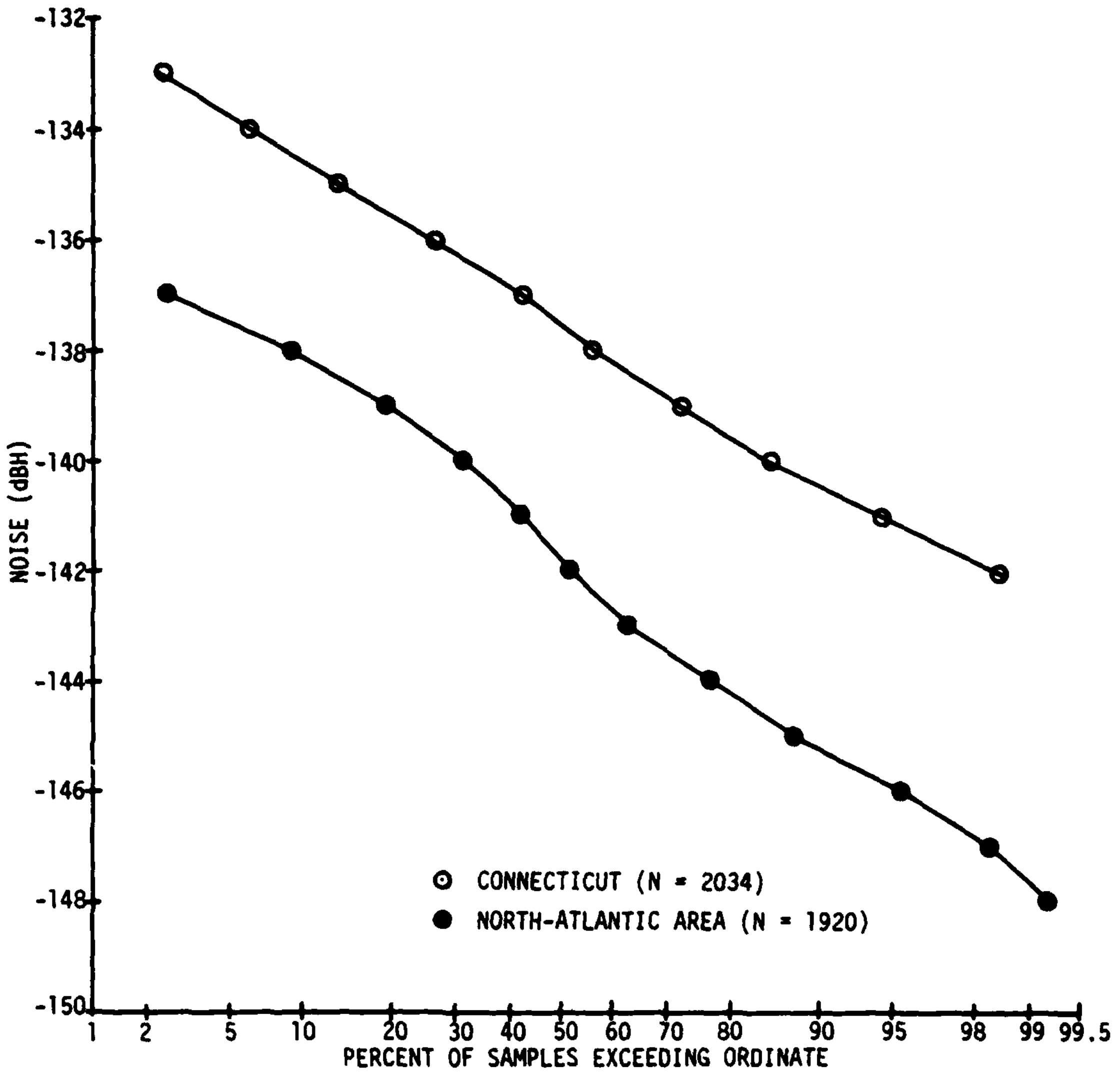

Figure 18. Comparison of September 1976 Effective-Noise APD's

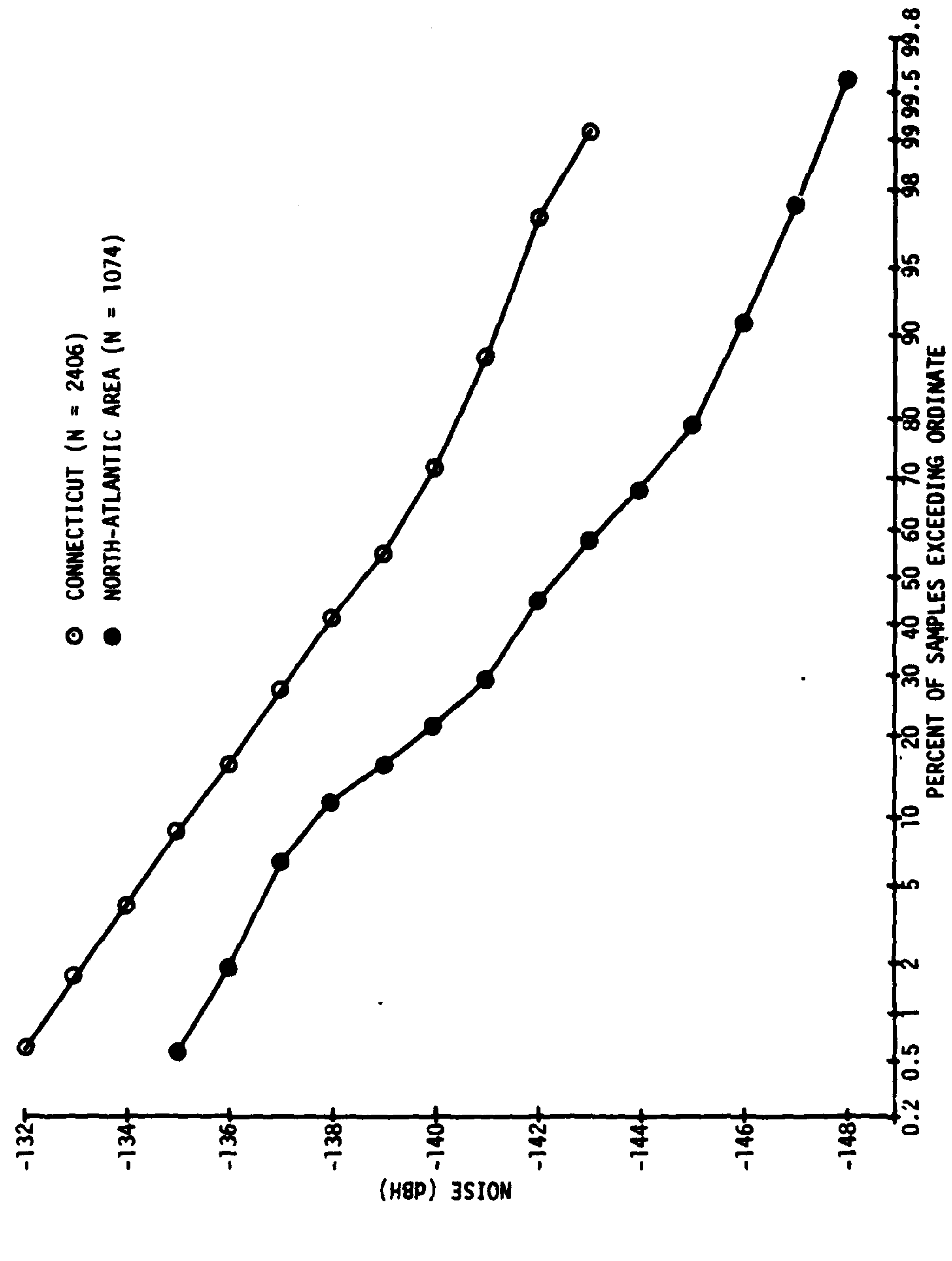

Figure 19. Comparison of October 1976 Effective-Noise APD's

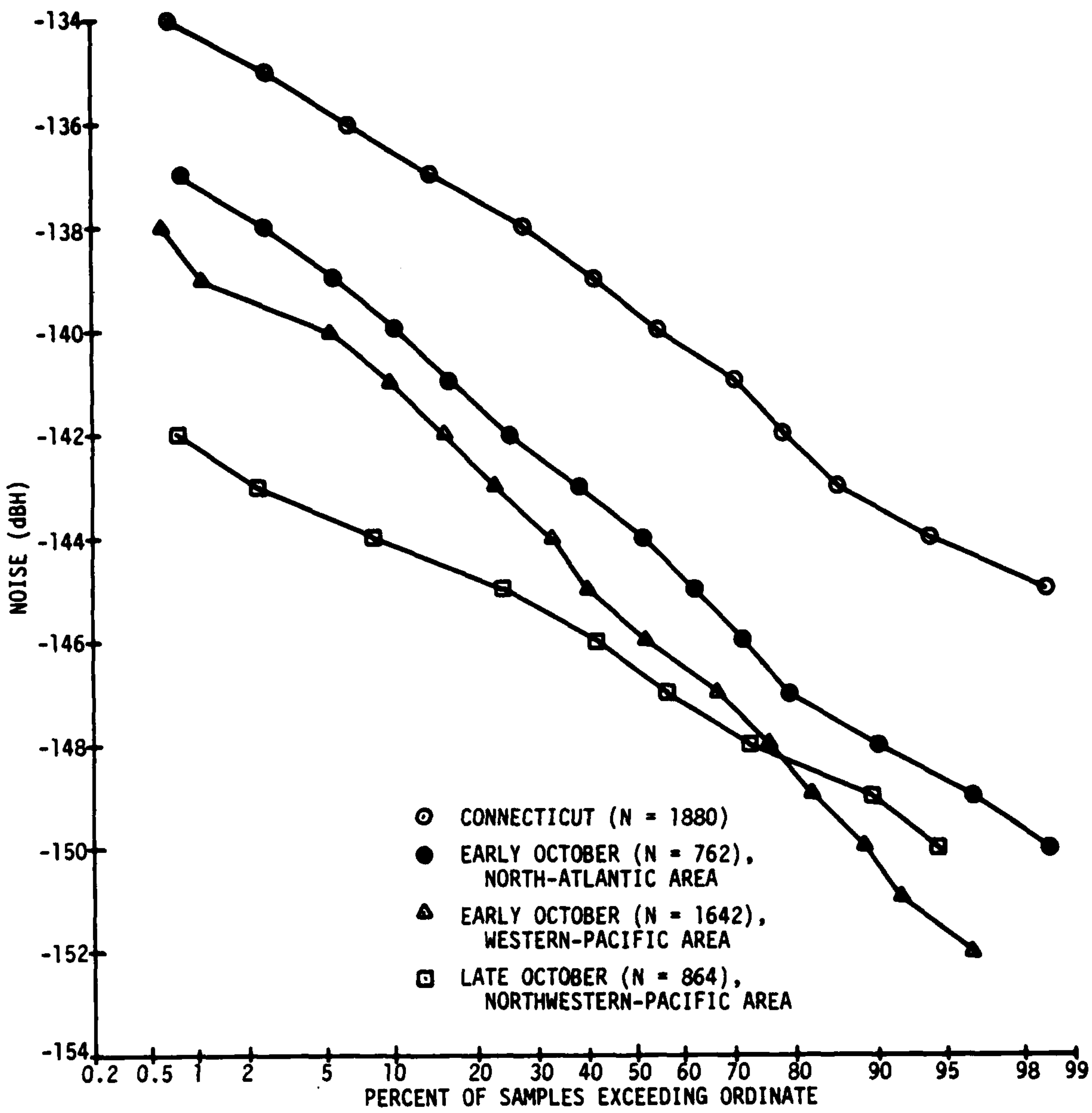

Figure 20. Comparison of October 1977 Effective-Noise APD's

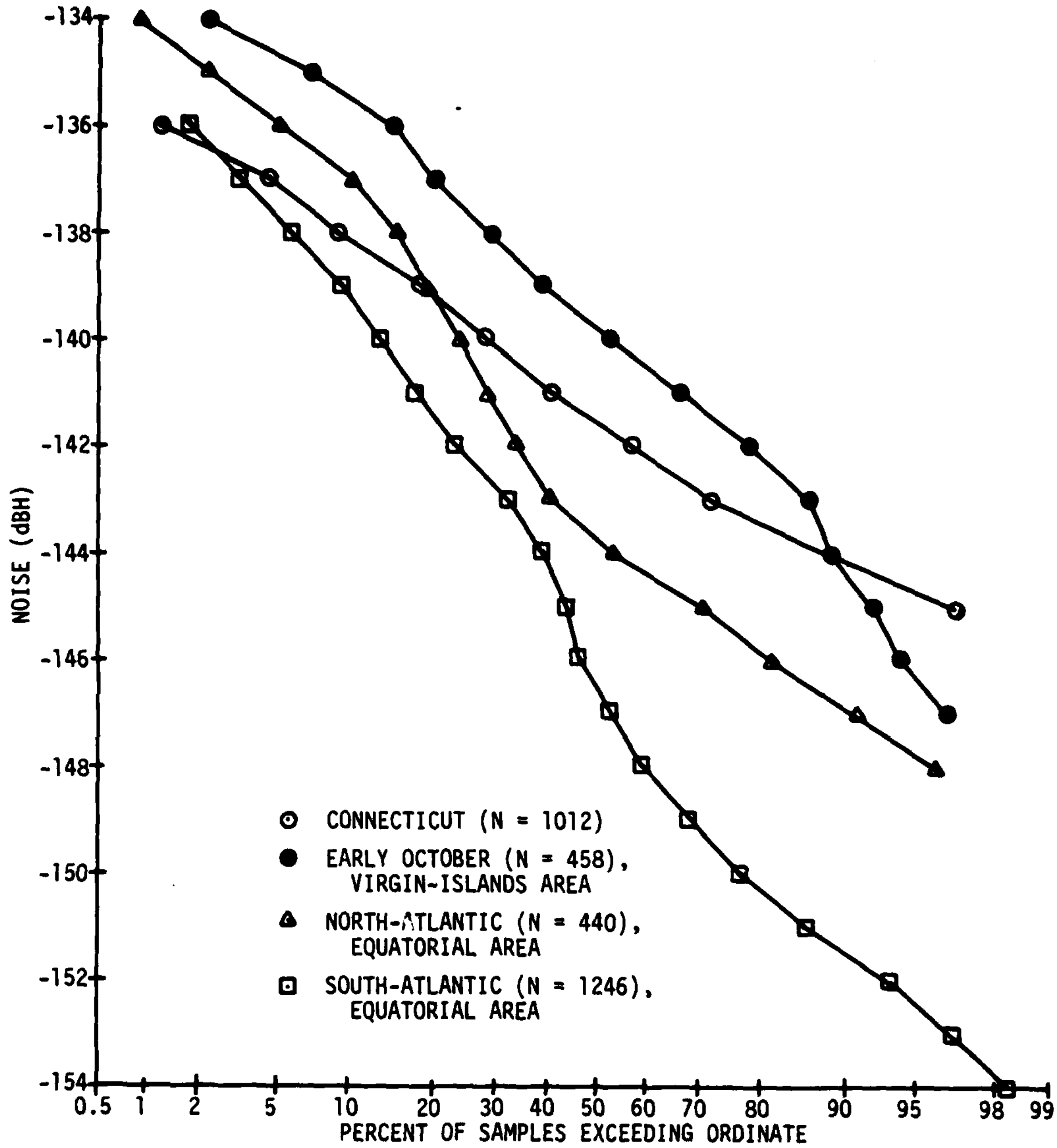

Figure 21. Comparison of October 1978 Effective-Noise APD's

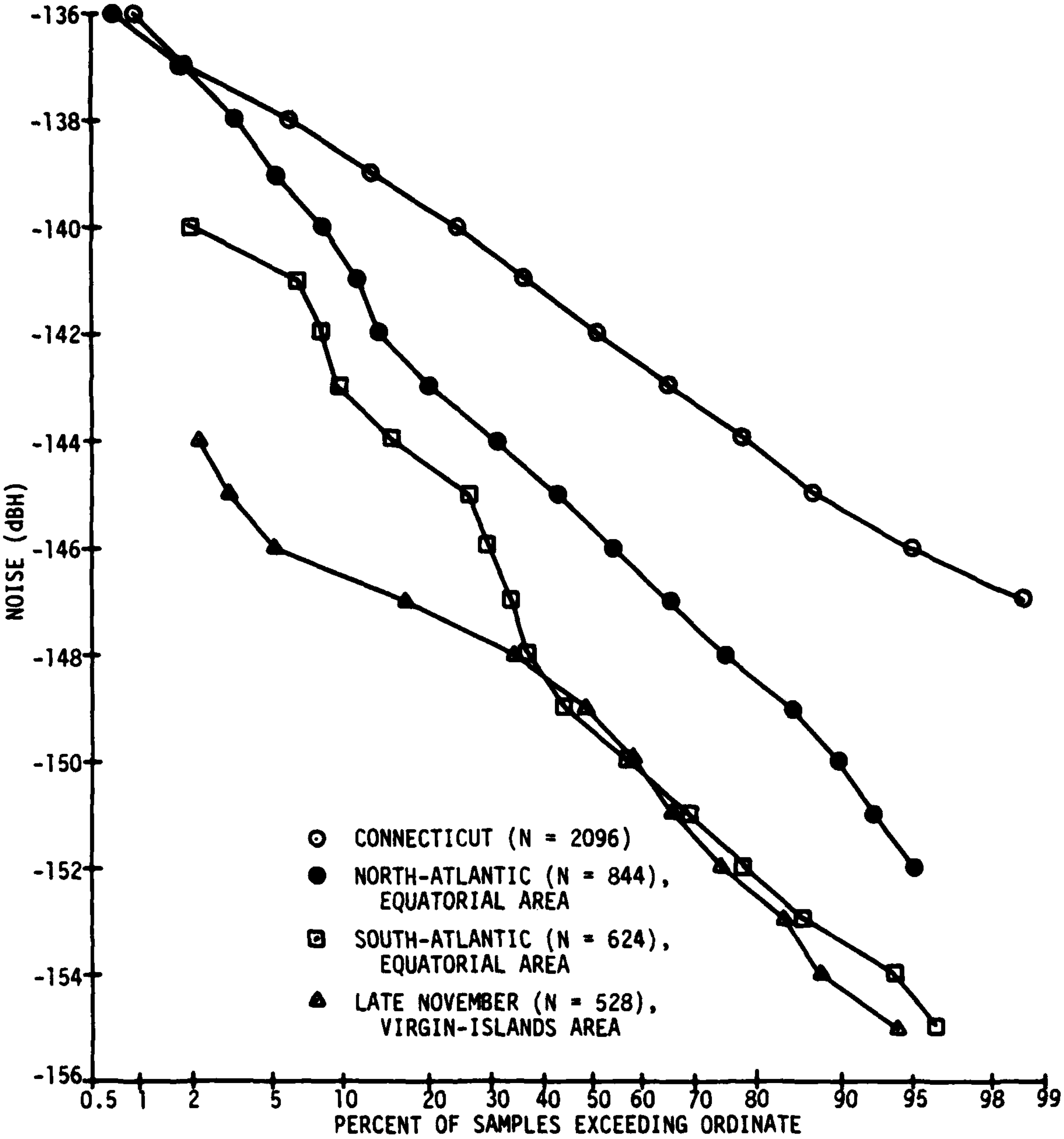

Figure 22. Comparison of November 1978 Effective-Noise APD's

REFERENCES

1. J. E. Evans and A. S. Griffiths, "Design of a Sanguine Noise Processor Based Upon Worldwide ELF Recordings," IEEE Transactions on Communications, vol. COM-22, no. 4, 1974, pp. 528-539.

2. P. R. Bannister, ELF Effective Noise Measurements Taken in Connecticut During 1976, NUSC Technical Report 5681, Naval Underwater Systems Center, New London, CT, 5 August 1977.

3. A. S. Griffiths, Measurements of ELF Noise Processing, Technical Note No. 1975-33, MIT Lincoln Laboratory, Lexington, MA, 2 September 1975.

4. P. R. Bannister, ELF PVS Field Strength Measurements, January 1977, NUSC Technical Report 6879, Naval Underwater Systems Center, New London, CT (to be published).

5. P. R. Bannister, ELF PVS Field Strength Measurements, March 1977, NUSC Technical Report 6769, Naval Underwater Systems Center, New London, CT, 3 February 1983.

6. P. R. Bannister, ELF PVS Field Strength Measurements, April 1977, NUSC Technical Report 6771, Naval Underwater Systems Center, New London, CT, 3 February 1983.

7. P. R. Bannister, ELF PVS Field Strength Measurements, October 1977, NUSC Technical Report 6773, Naval Underwater Systems Center, New London, CT, 3 February 1983.

8. P. R. Bannister, ELF PVS Field Strength Measurements, January/February 1978, NUSC Technical Report 6775, Naval Underwater Systems Center, New London, CT, 3 February 1983.

Appendix

CONNECTICUT 1976 TO 1978 EFFECTIVE-NOISE AMPLITUDE-PROBABILITY DISTRIBUTIONS

Connecticut effective-noise amplitude-probability distributions for 1976 to 1978 are presented in this appendix as figures A-1 through A-12.

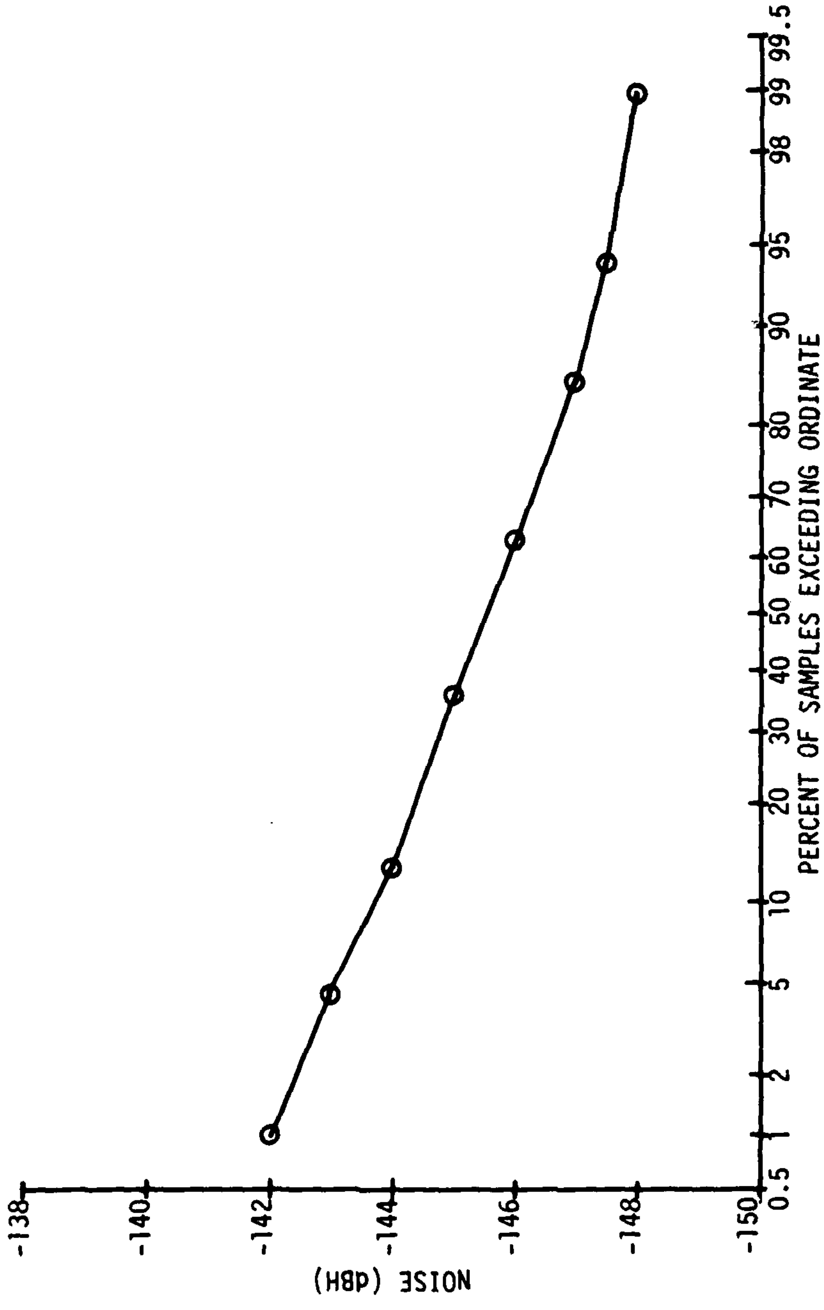

Figure A-1. Connecticut January 1977 Effective-Noise Distribution (N = 948)

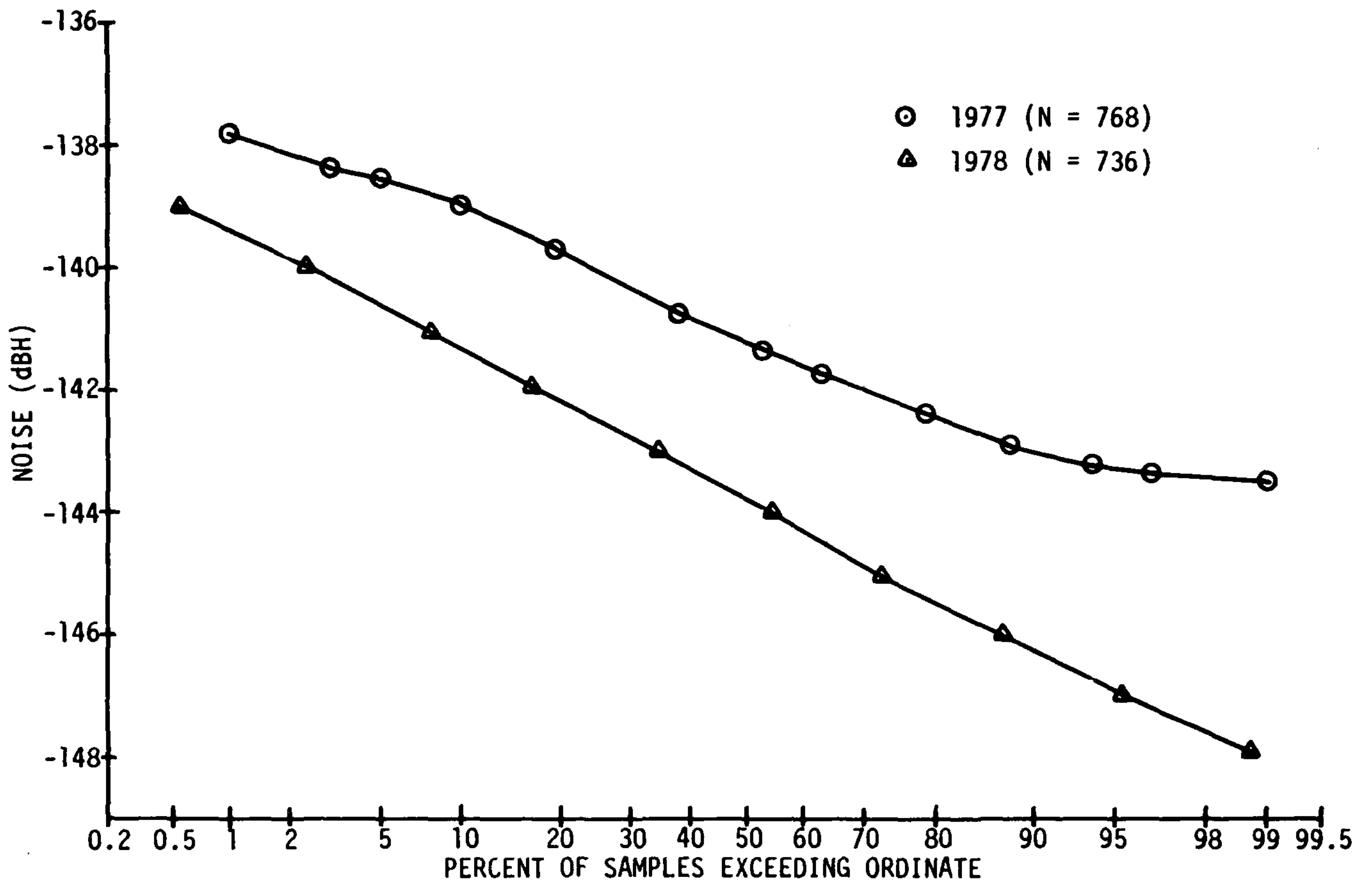

Figure A-2. Connecticut February 1977 and 1978 Effective-Noise Distributions

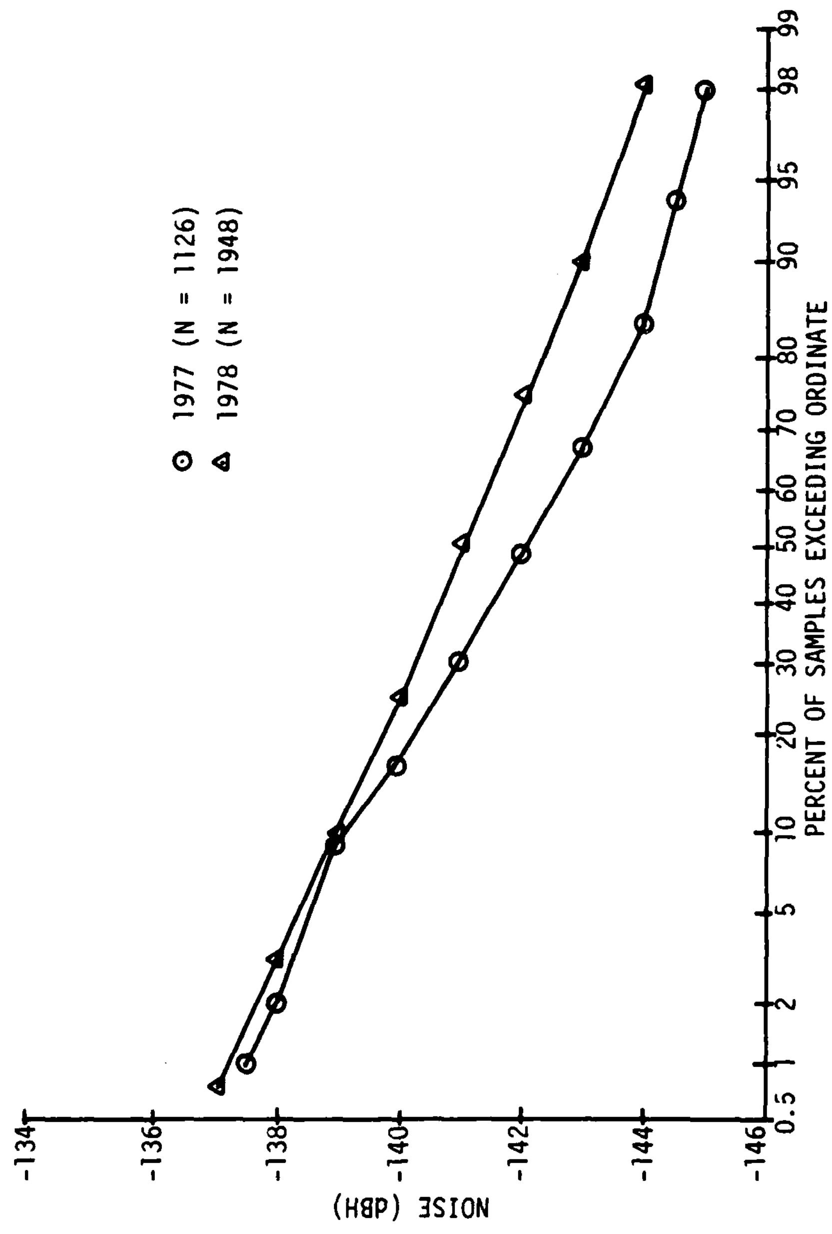

Figure A-3. Connecticut March 1977 and 1978 Effective-Noise Distributions

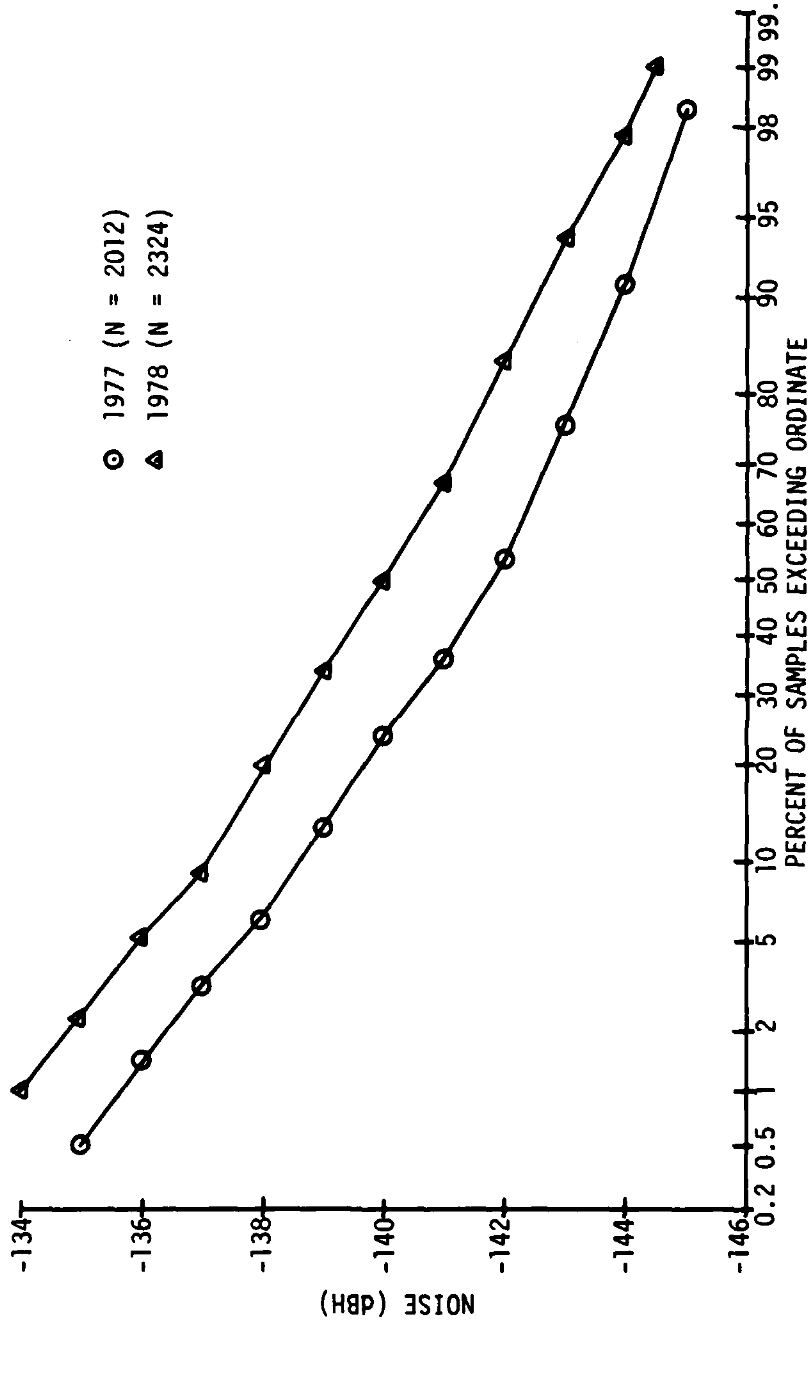

Figure A-4. Connecticut April 1977 and 1978 Effective-Noise Distributions

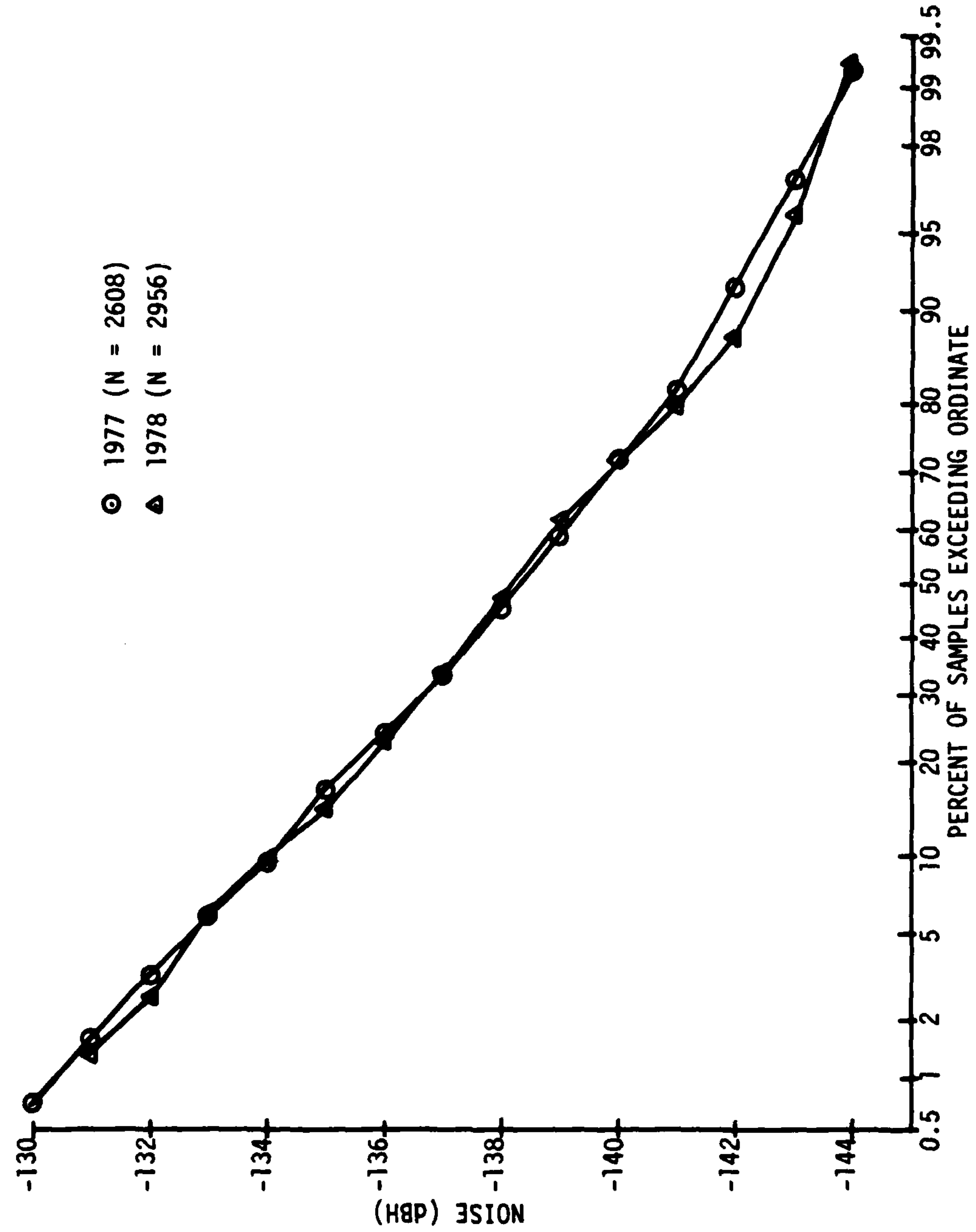

Figure A-5. Connecticut May 1977 and 1978 Effective-Noise Distributions

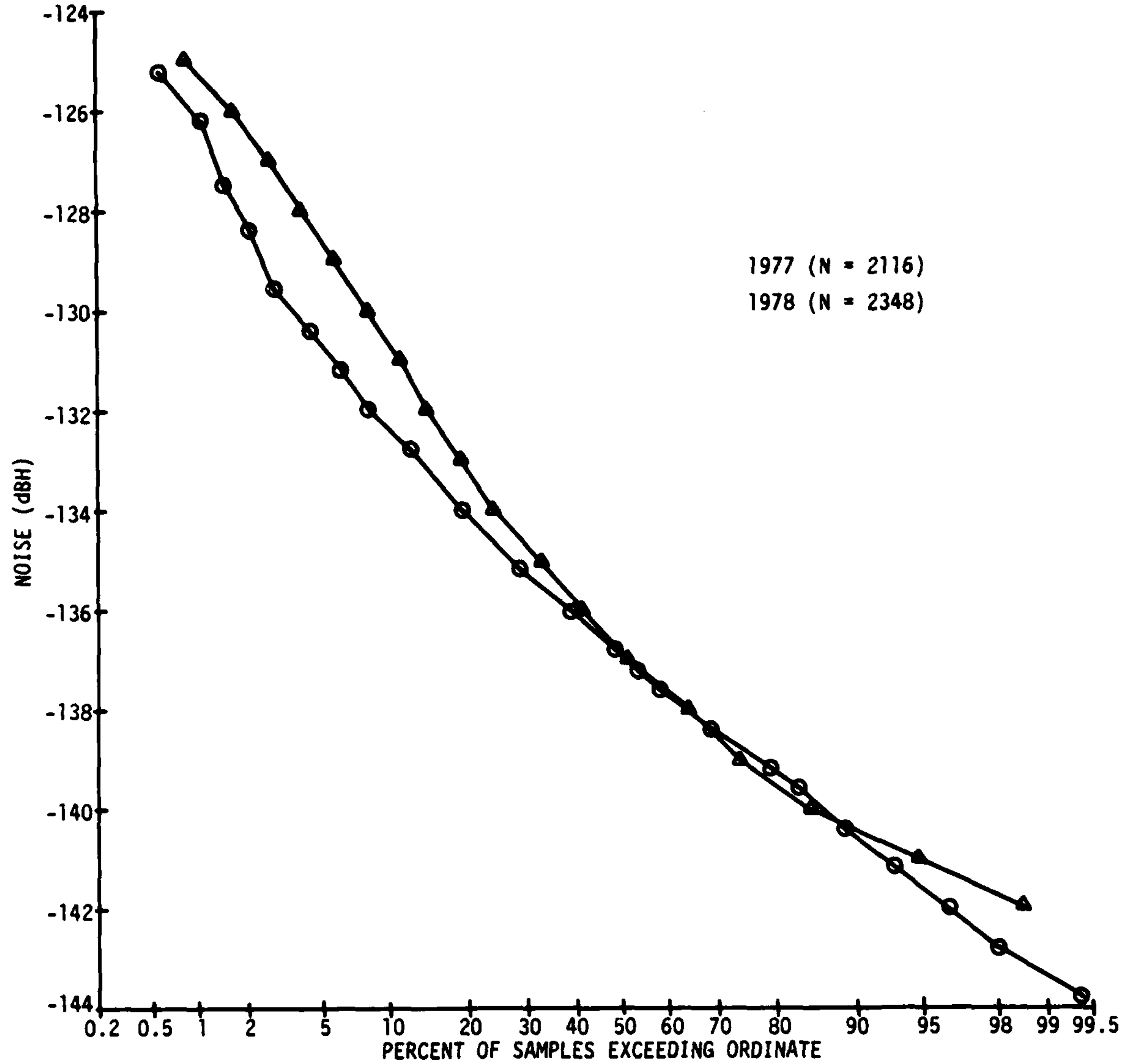

Figure A-6. Connecticut June 1977 and 1978
Effective-Noise Distributions

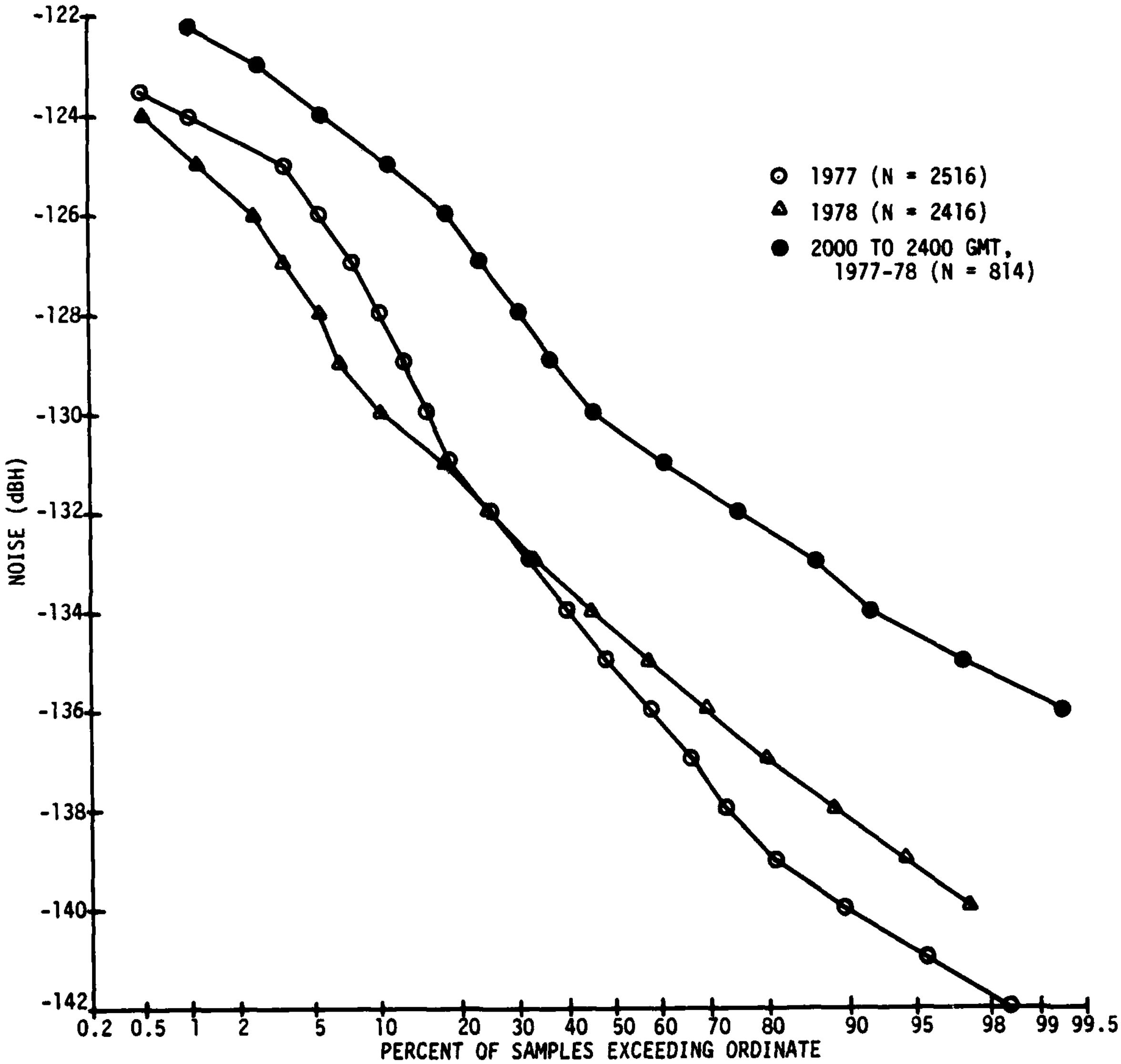

Figure A-7. Connecticut July 1977 and 1978
Effective-Noise Distributions

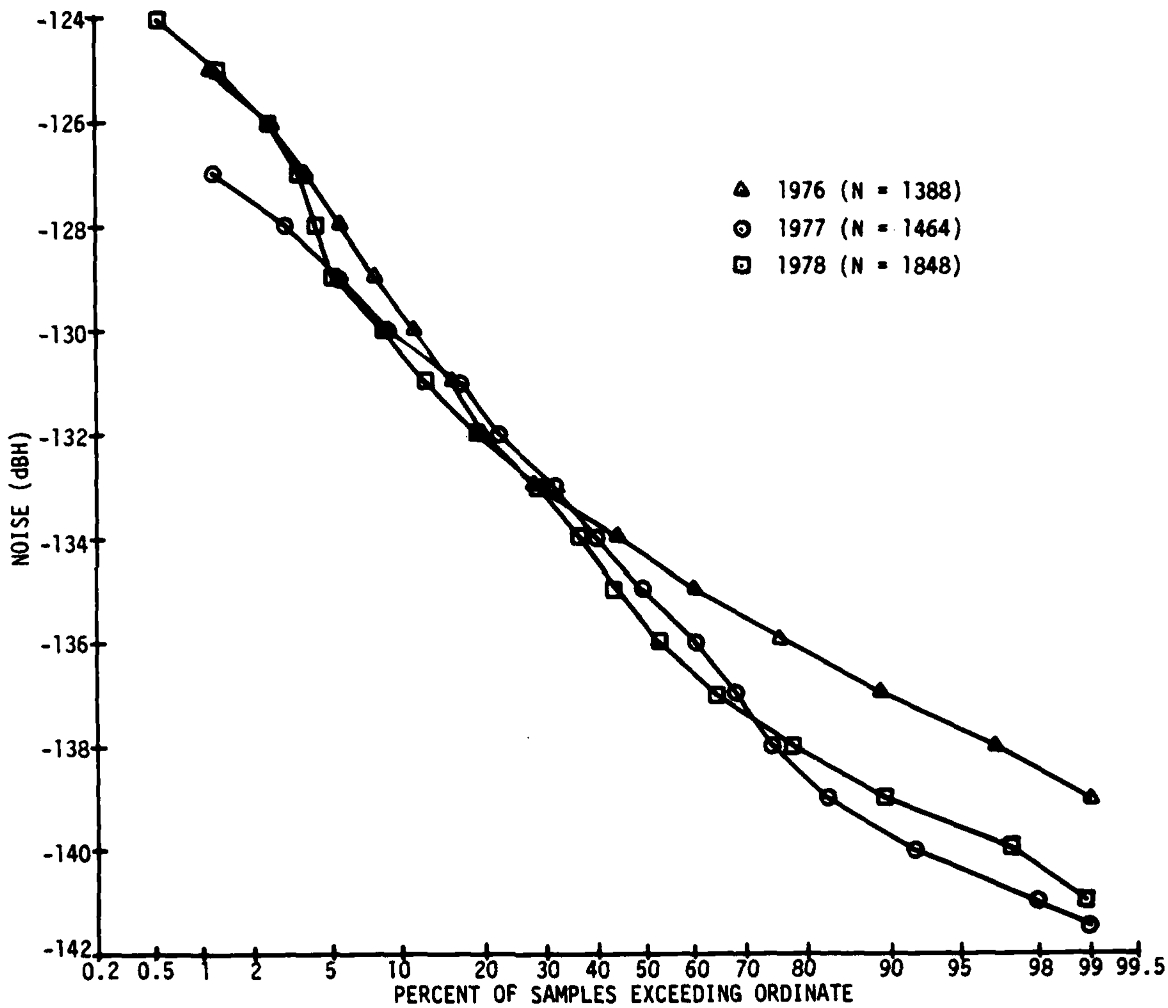

Figure A-8. Connecticut August 1976, 1977, and 1978 Effective-Noise Distributions

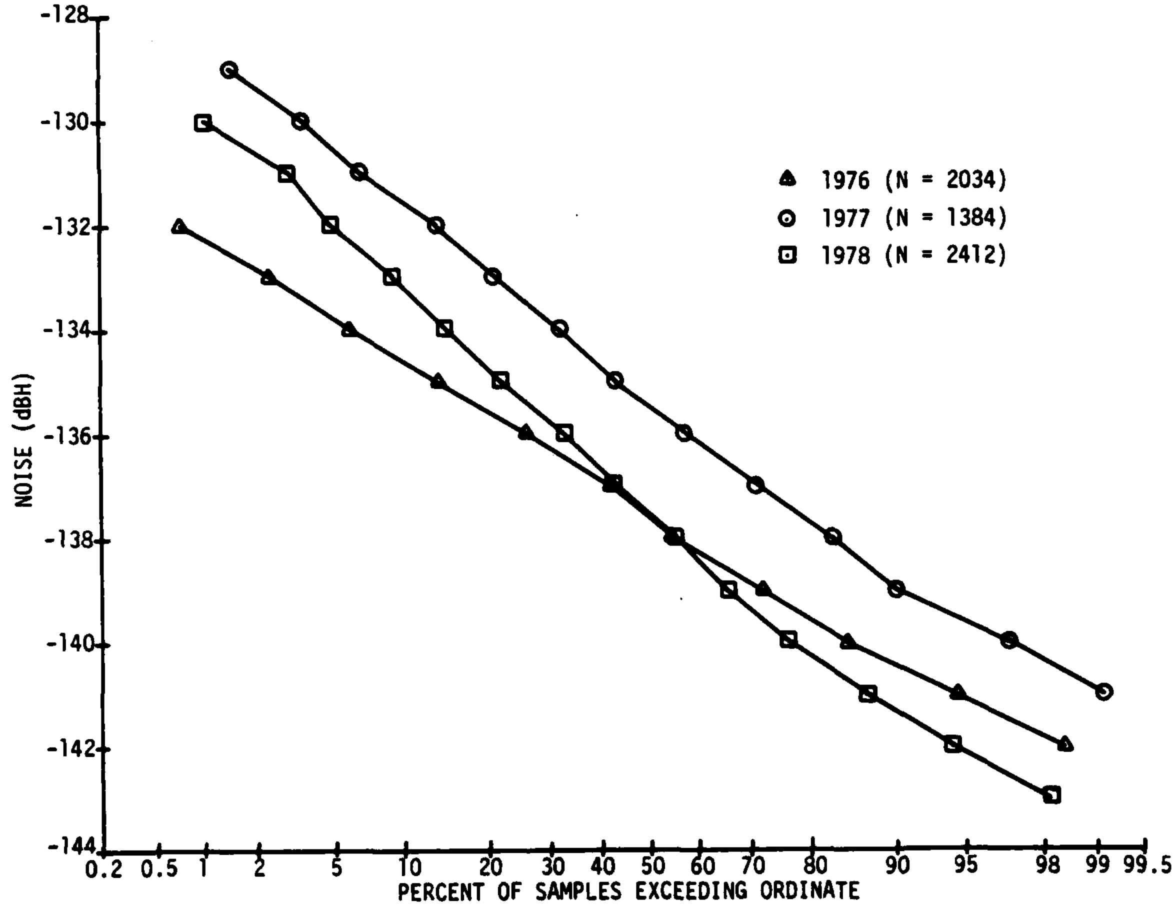

Figure A-9. Connecticut September 1976, 1977, and 1978 Effective-Noise Distributions

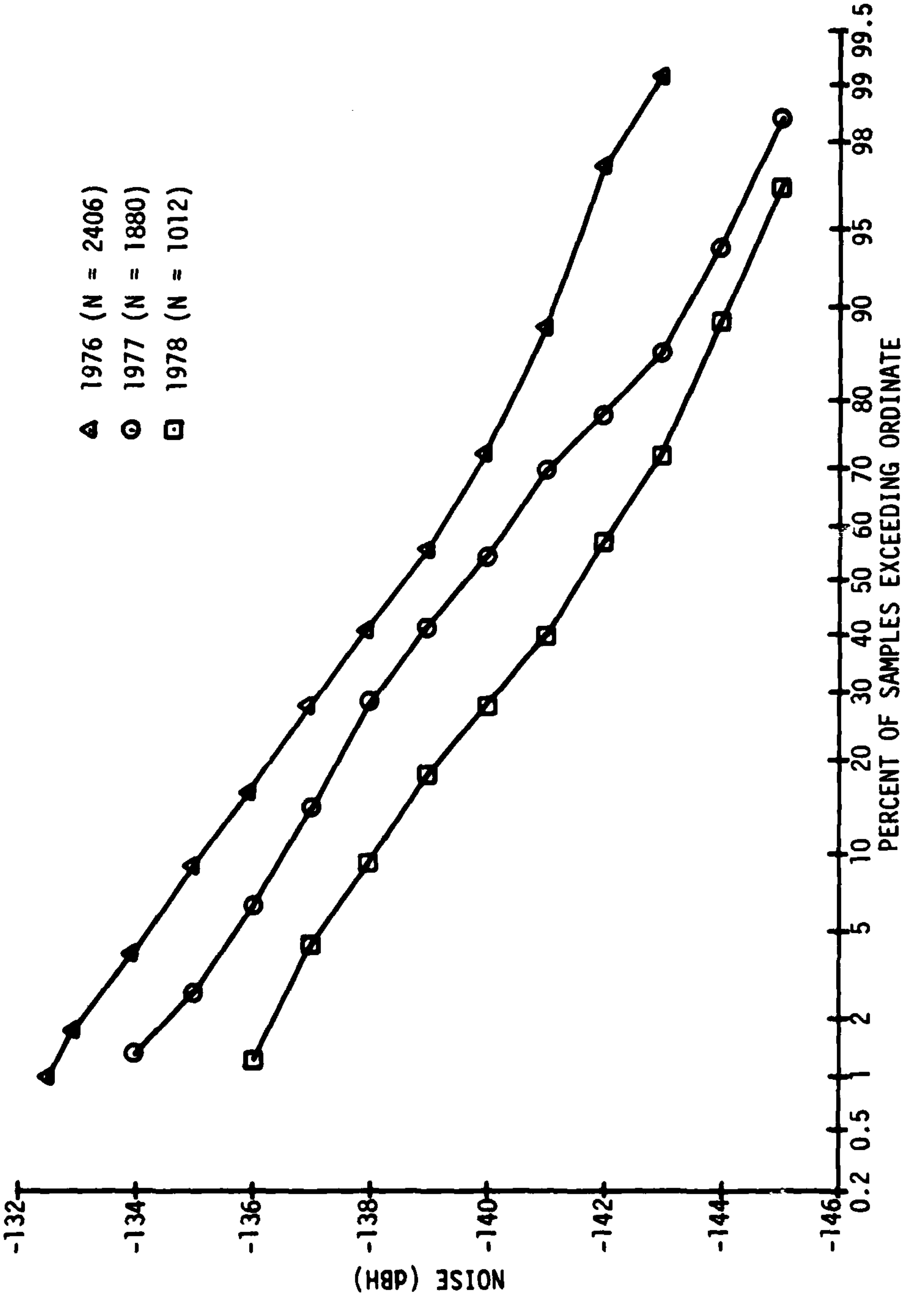

Figure A-10. Connecticut October 1976, 1977, and 1978
Effective-Noise Distributions

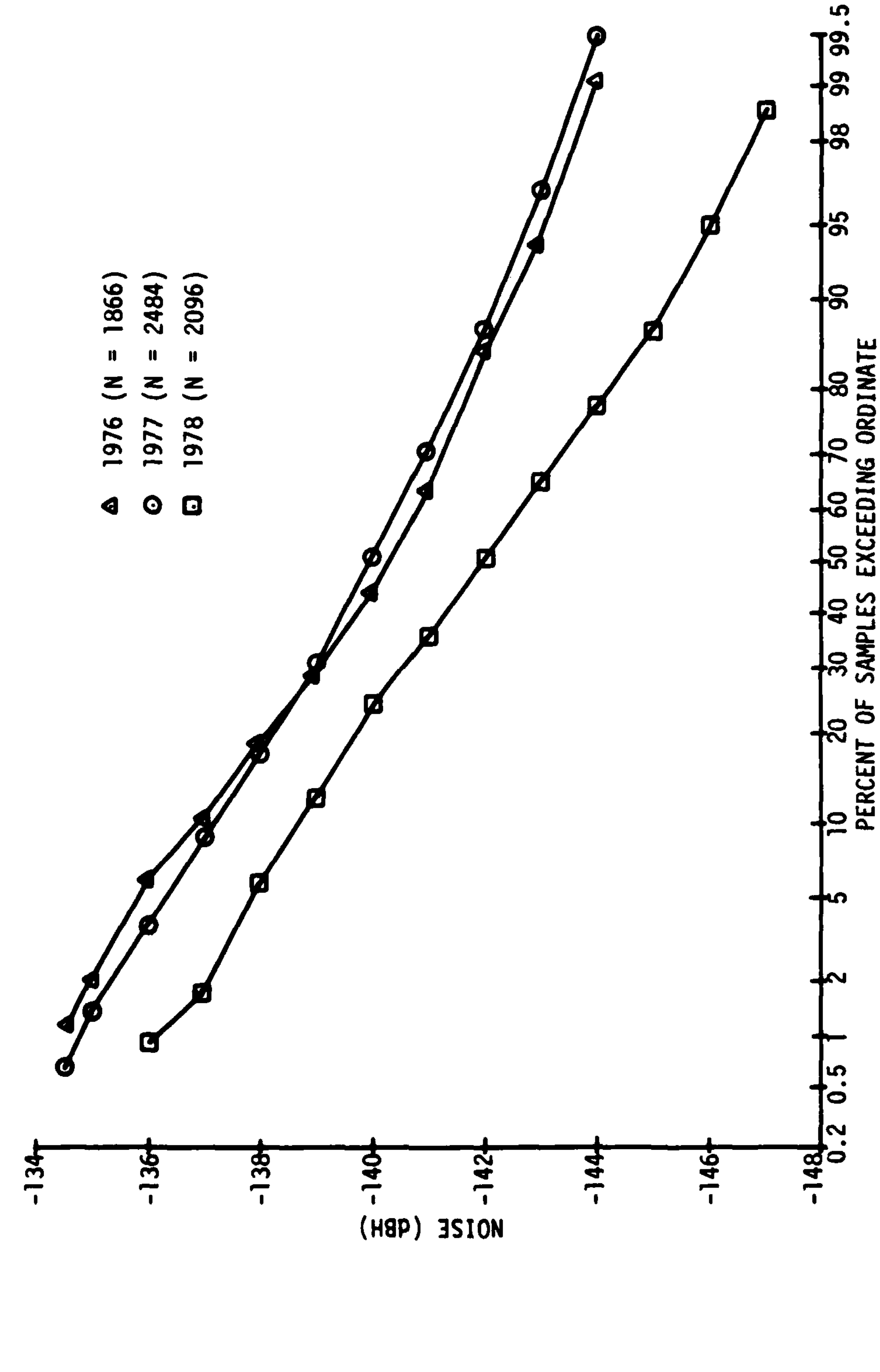

Figure A-11. Connecticut November 1976, 1977, and 1978 Effective-Noise Distributions

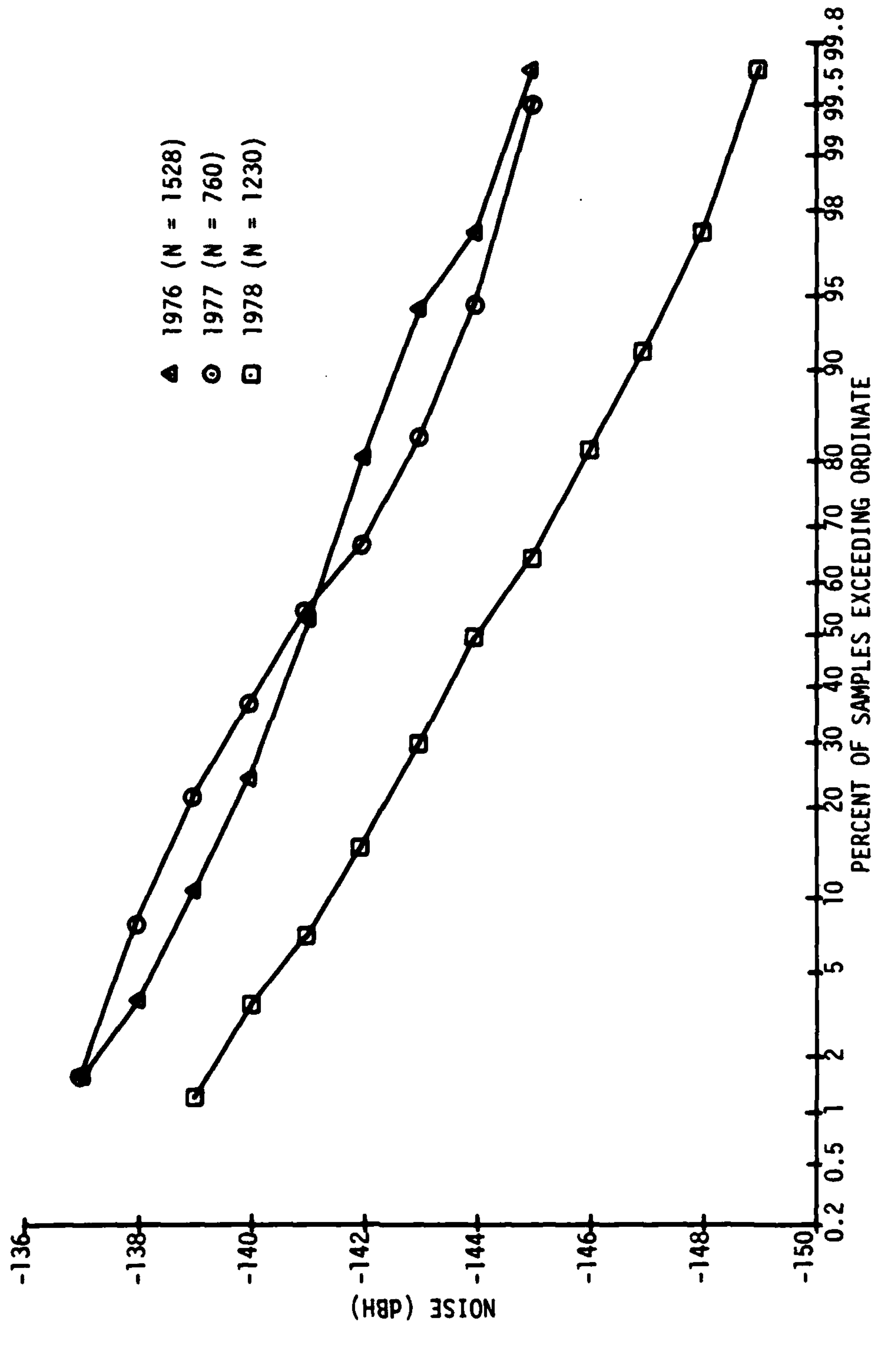

Figure A-12. Connecticut December 1976, 1977, and 1978 Effective-Noise Distributions

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